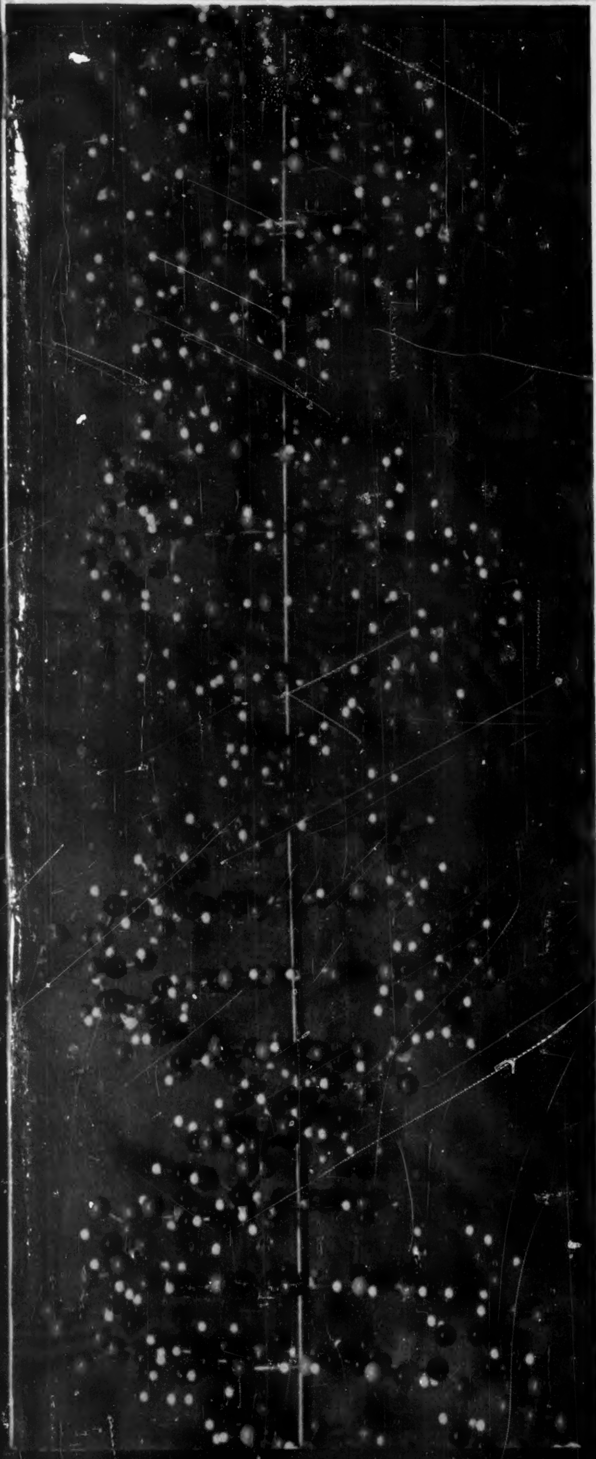
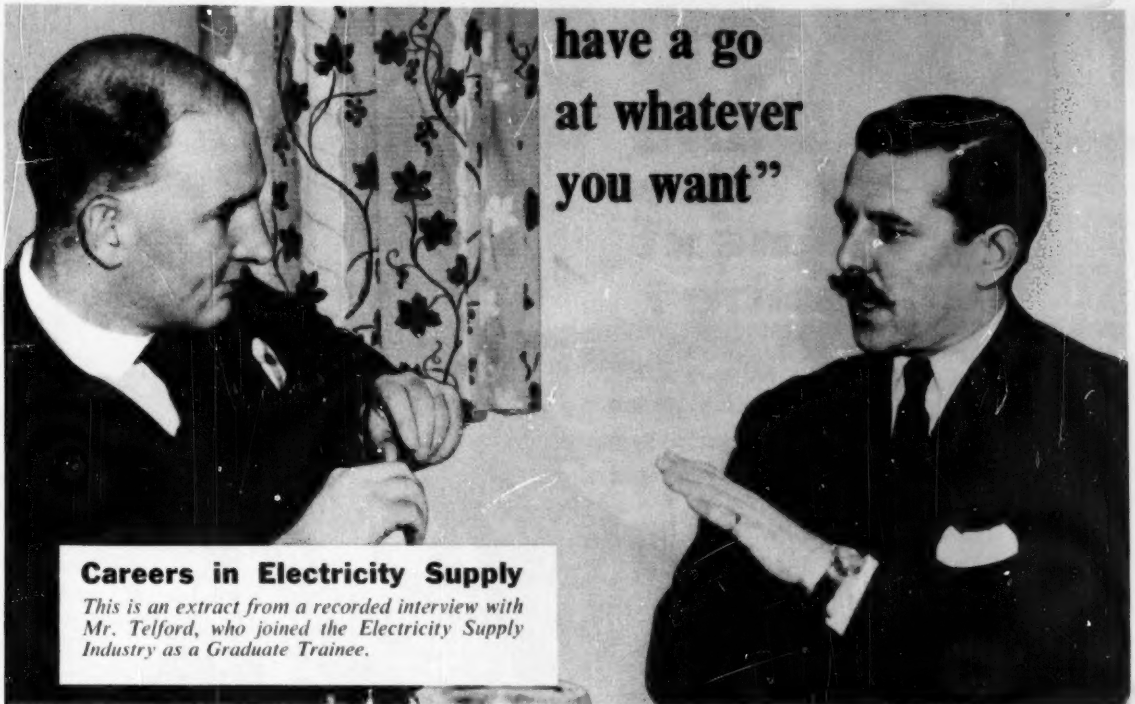
DISCOVERY

JANUARY 1958 **2/6**



"...you can have a go at whatever you want"



C.E.A. Question Master *Mr. Telford*

Question Master: **I think we might begin by asking what was your first job in Electricity Supply after your training was finished?**

Mr. Telford: Well, my training was interrupted by the war, and it was only in 1950 that I finished my graduate course in the industry. I was then appointed Shift Charge Engineer at Frome, Somerset—a small station but an excellent training ground. From there I went to Earley—a much bigger station of 120 megawatts—as Boiler House Shift Engineer: later I became Charge Engineer there, and for a while was Efficiency Engineer, as well.

Q.M.: **Your next step was London, wasn't it?**

Tel.: Yes, I came to London as Second Assistant Engineer on the Divisional Staff, and later I was appointed Deputy Superintendent at Bankside Generating Station—the position which I hold now.

Q.M.: **Bankside is a pretty big station, and at 36 you're young, aren't you, to be a Deputy Superintendent? But what made you come to London in the first place?**

Tel.: A chance came along to get some administrative experience at H.Q. level, and I thought I'd better take it.

Q.M.: **Does the Industry give many opportunities like that?**

Tel.: It most certainly does. It gives you a complete opportunity to have a go at whatever you want, and what you think you're best equipped for. The man who wants to get on is helped in every possible way; I've attended several courses run by the Authority, not only on technical matters, but on subjects like personnel selection and industrial relations.

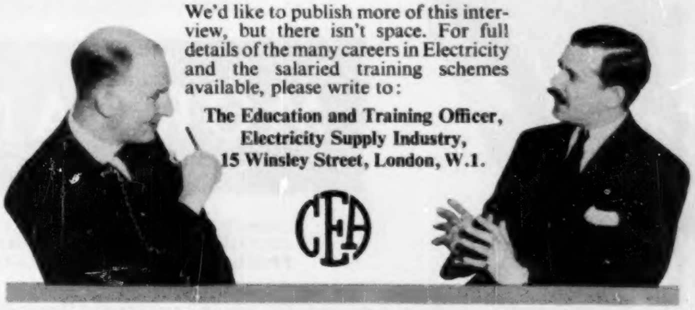
Q.M.: **You find your job gives you scope for managerial ability—dealing with people as well as machines?**

Tel.: Yes, indeed. I don't think there are many better opportunities than in a power station, because you have something of everything. You have the mechanical side, the electrical side, the building side—and most of all, a number of people with varied interests and jobs.

Q.M.: **Now a word about newcomers to the industry. If you have a chap of ability who is prepared to get down to the task, what would you say his opportunities were like?**

Tel.: I would say that he has really splendid opportunities. For one thing, a career in the industry is established on a very firm footing—you could do without a lot of things, but it's impossible to get on nowadays without electrical energy.

Another point worth remembering is that a man coming into the industry has the choice of the entire country to work in–England, Scotland and Wales—and there's no parochial approach.



DISCOVERY

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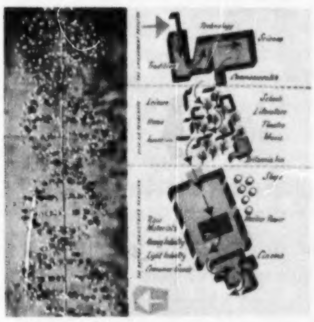

On the left, model of a deoxyribonucleic acid molecule, an exhibit for the United Kingdom Pavilion at the Brussels Exhibition. *On the right*, the plan of the U.K. part of the Exhibition.

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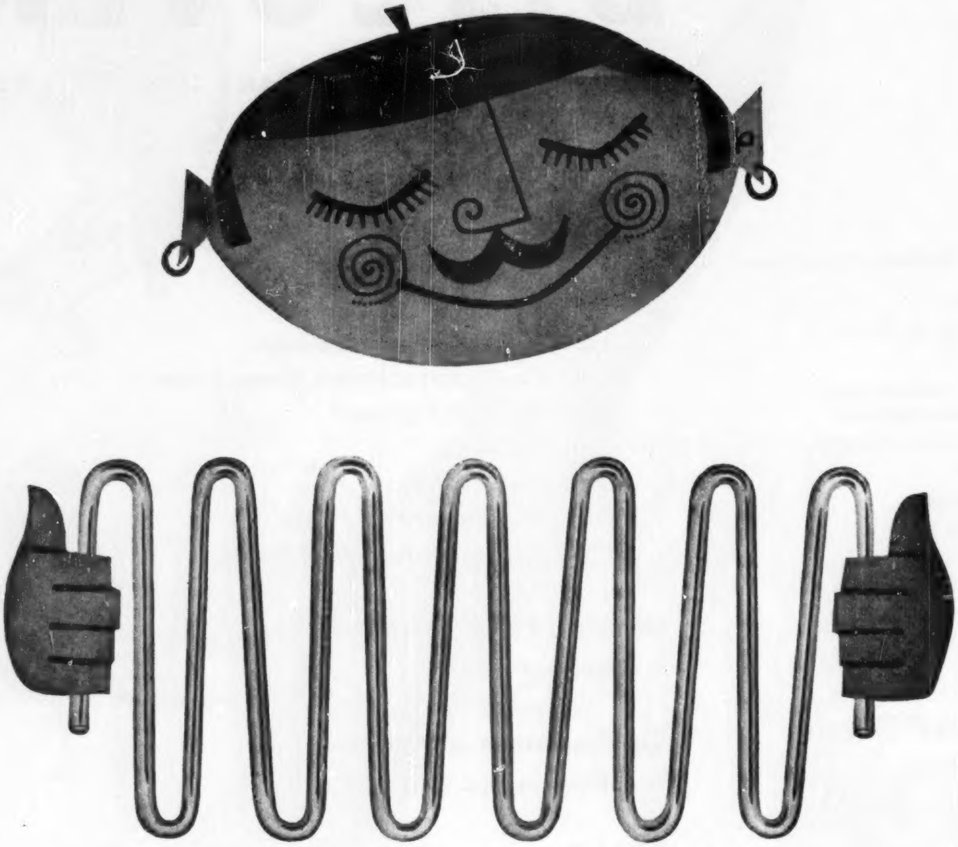


THE PROGRESS OF SCIENCE

THE FUTURE AND THE STRATEGY OF SCIENCE

The future is the scientist's business. All his work, all his experiments, are directed forward in order to find new knowledge to be used in time to come. This obvious thought needs stressing and applying. Too many people think of the past, of what has gone before, and try to live by the concepts of the past. A beginning must be made, and the most important beginning is in the field of science itself. It is through science alone that a better future can be created.

Up to the present there has been no strategy of science. Science has—like other successful human enterprises or a biological specimen—grown rapidly and in any direction it liked, provided money, its nutrient, was available. During the last two hundred years, science has roughly doubled in size every ten years, an exponential growth which cannot continue at its present rate. As yet there is no shortage of nutrient, but it is the limited manpower of scientists themselves which acts already as a powerful brake on its continued expansion. Determined efforts are being made in England and elsewhere to increase the number of scientists by trying to attract more boys to its careers, by building more technical colleges and by raising the social and financial status of scientists. But that is only a tactical device. It will merely postpone the date, and that only by a few years, when the expansion of science comes to an end, and growth will cease.

Yet, the demands on science will continue to expand. All aspects of our lives, our civilisation and our economy are utterly dependent on science, and this will demand a continually increasing effort from scientific research if progress is to be maintained, let alone accelerated. With a limitation of manpower on the one hand, and a demand for increasing effort on the other, there can only be one solution. A Strategy of Science must be devised. This is no new problem for scientists, who have often been called upon to expand production with strictly limited resources, but few have yet considered this as a dilemma applying to themselves, their own work, and their own profession. Now is the time to frame the outlines of a strategy for science, while we have still a few more years of natural expansion in front of us, when they have passed it will be too late.

Right from the beginning a clear distinction must be made between strategy and tactics. There are many tactical questions of great importance to be solved. For example, can information-theory help to produce a more efficient flow of thought between scientists and rationalise the scientific literature? Can design be carried out by electronic devices? Can operational research techniques be more widely applied in industry? Can automation play its full part in the laboratory? How can research be best administered? Is enough attention being paid to the teaching of research techniques as distinct from research itself? All these and many similar questions are of the utmost importance, but in this context merely tactical aids to solve the strategical problem.

A strategy of science can only have one aim: to produce the maximum of effort from available resources. This may well mean an assessment of the relative importance of scientific subjects and the allocation of priorities. As a corollary it may mean that research in some fields will have to come to a halt. If a strategy of science is to be devised, machinery will have to be created and a full study be made of all the relevant aspects. In fact science will have to apply scientific methods to itself.

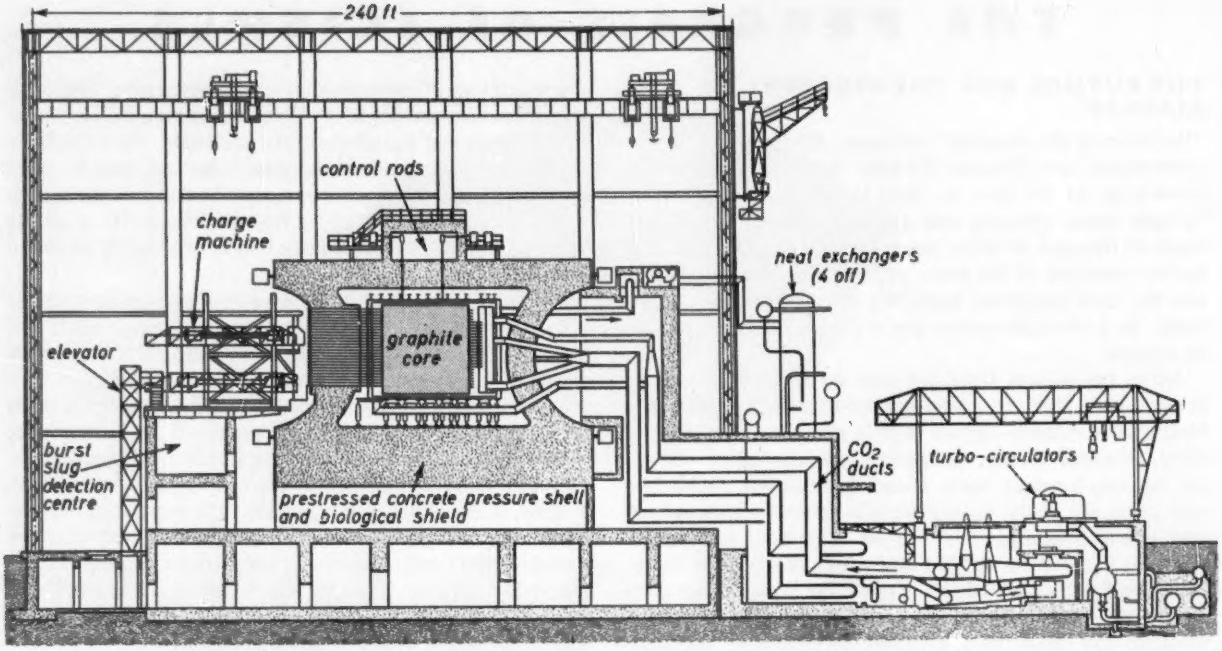
To begin with, it must observe itself dispassionately, it must be prepared to postulate hypotheses about itself and its own future, and to test their validity by carefully planned control experiments. It must learn to judge its own efficiency and to discard ruthlessly subjects and techniques which have been proved of no value. It must define its values and standards of judgment, but it must be prepared to revise them continually in the light of new knowledge. Finally, if any strategy of science is to be successful, science must learn to communicate efficiently with its own disciples and the community as a whole, upon whose support it must inevitably depend. Without this support, science will not find the money for its continued growth, an essential condition for the survival of this country.

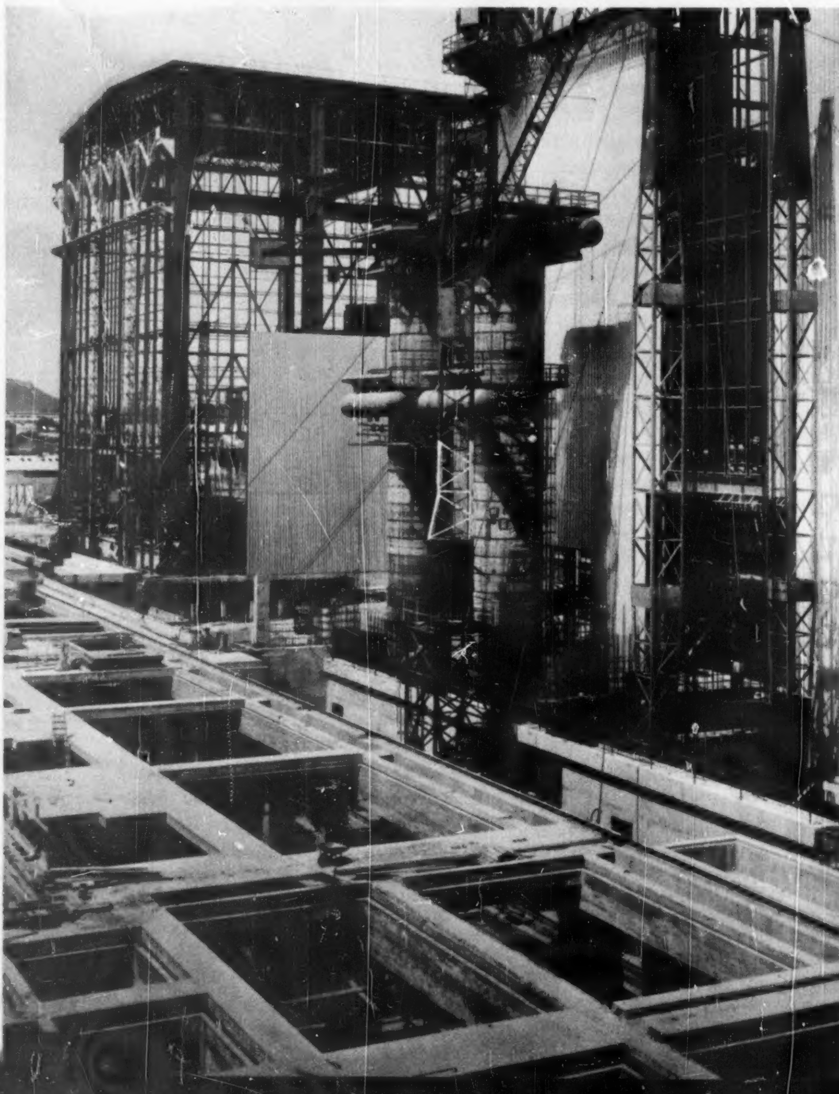
MARCOULE—CENTRE OF FRENCH ATOMIC POWER

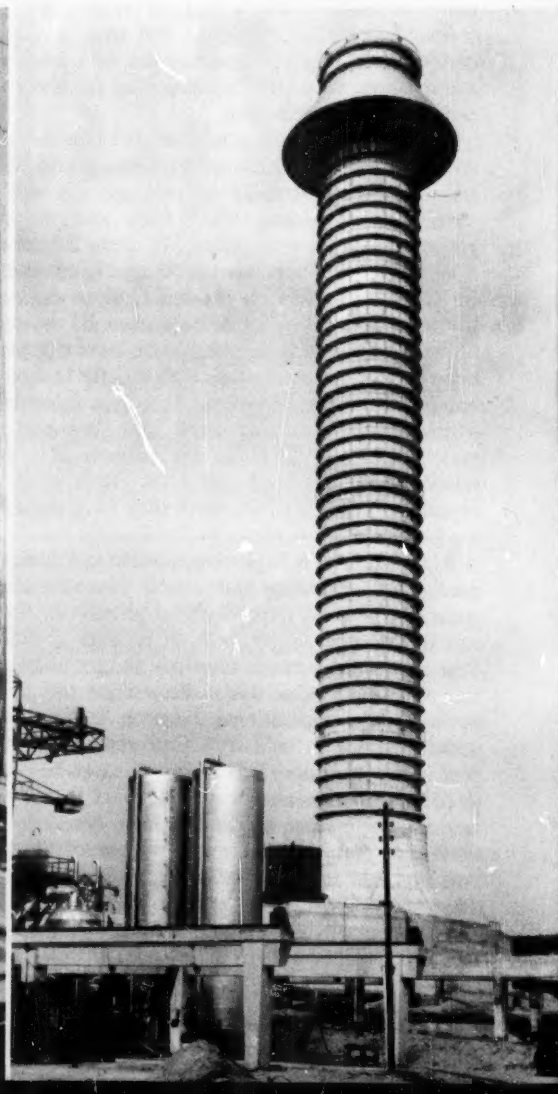
Marcoule, about twenty miles north-west of Avignon, is the centre of French atomic power production, with a plant equal to the activities of Windscale and Calder Hall.

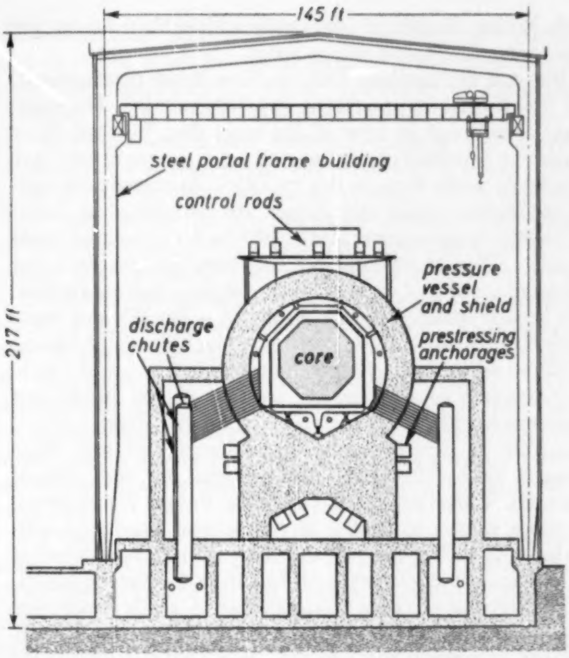
The production at Marcoule is optimised for plutonium. Three reactors, G1, G2, and G3, are in being. G1 is actively working, G2 practically finished, and G3 soon to be completed. G1, like Windscale, is cooled by natural air. There are 1337 channels provided for uranium rods encased in pure magnesium cans with longitudinal fins. Boron carbide control rods are provided, and the pressure of the circulating air is one atmosphere with 180°C outlet air temperature.

G2 and G3, identical reactors, differ in principle from the standard British ones, which use vertical rods of uranium. The French designers desired to use horizontal rods enclosed in a three-metre thick concrete shield. This biological shield is lined on its inside with a gas-tight metal container and thus avoids the need for a separate metal pressure container which is standard practice at Calder Hall, Hinkley Point, and the other British reactors. The concrete shield of G2 has been carefully prestressed with cables running the whole length of the reactor. The reactor contains uranium rods in pure magnesium cans with longitudinal fins, the rods themselves have 28 mm. diameters in the centre and 31 mm. outside. The pressure inside the reactor will be 15 atmospheres and the temperature limit, 400°C in the can. The output of the reactor through conventional heat exchangers, steam turbines, and electric generators, will be 50 megawatts, of which 30 megawatts will be sent to the French electricity grid. Both G2 and G3 will contribute greatly to the plutonium production of France, but it has not disclosed whether the plutonium will be used for the production of bombs or for advanced reactors. It is likely that it will be used for both purposes.


240 ft
control rods
charge machine
heat exchangers (4 off)
graphite core
elevator
burst slug detection centre
prestressed concrete pressure shell and biological shield
CO_2 ducts
turbo-circulators



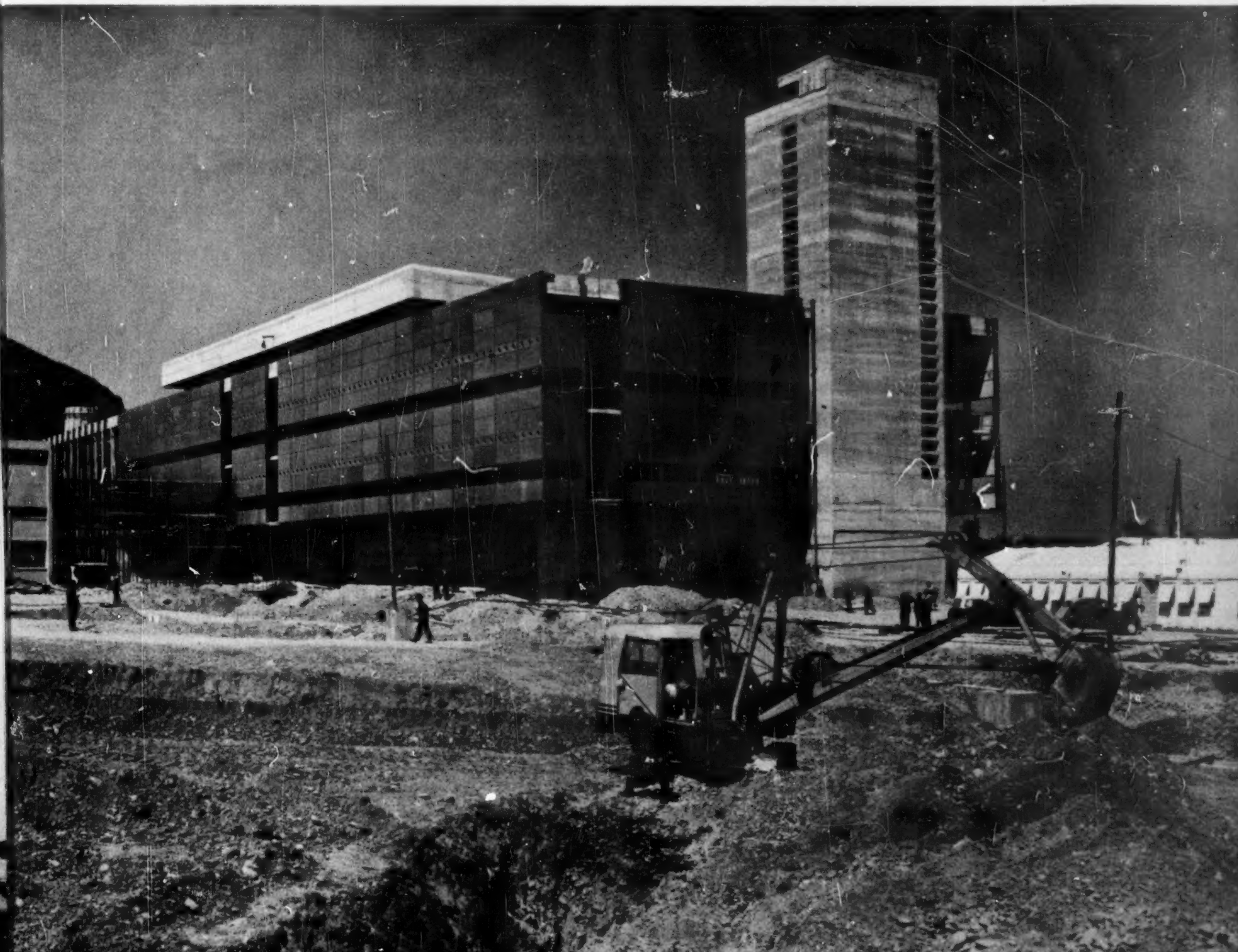




MARCOULE– CENTRE OF FRENCH ATOMIC POWER

On the left: sectional elevations through the G2 reactor show the main features of the design. Note the massive prestressed concrete pressure vessel which also provides a biological shielding. (Reproduction by kind permission of the Editor of *Nuclear Power*, 1957, vol. 2, No. 17, p. 358.)

Below, left: The east faces of the G2 and G3 reactors, showing the erection of the heat exchangers. *Below, centre:* The chimney of the G1 reactor. *Below:* The plutonium separating plant.



10^{-7} INCH FOR THE ENGINEER?

In general, scientists today are not so ready as in the past to deny that those who spend their working hours in advancing the art of measurement find their task exhilarating and satisfying. But whether the enthusiasm of success sometimes leads to flights of fancy which are more academic than practical is always a question worth asking.

A decade ago, the measurement of mass was the metrologist's acme of perfection: he could determine one kilogram in terms of another with an accuracy of 1 part in 10^9. However, the steady improvement in the measurement of frequency has since placed mass in the second place, and the accuracy of 1 part in 10^{10} now possible in comparing two radar frequencies, is clearly a desirable asset in the establishment of a standard of time by reference to quartz oscillators and atomic clocks. And what of length, the third fundamental quantity in the mechanical system? While it remained tied to a material bar, such as the International Prototype Metre or the Imperial Standard Yard, progress was stultified; but the application of interferometry paved the way for the introduction of a natural standard of inherently finer precision than the man-made standards. It is not surprising then that an international advisory committee on the definition of the metre has recently recommended abandoning the present line standard in favour of a standard based on the vacuum wavelength of a certain radiation of the krypton-86 isotope. This new standard is probably reproducible to an accuracy approaching 1 part in 10^9, a distinct advance on the 4 parts in 10^7 associated with the International Prototype Metre and an even bigger advance on the Imperial Standard Yard.

For the engineer, who bases his finest measurements of length on slip gauges, the use of an optical standard confers a double blessing. Not only is there a gain in accuracy but the standard can be applied directly to measuring the separation of the flat, parallel faces of the slip gauges, if necessary in the inspection room itself. The various national standardising laboratories have for many years applied interferometry to the calibration of the highest grade slip gauges, international approval having been given in 1927 to the use of the wavelength of the cadmium-red radiation as a provisional standard. By thus abrogating the reference to the line standard, the obligation of transferring from line standard to end standard, always considered to be one of the most difficult metrological operations, was avoided; precision was thereby improved. If, as is most likely, the recommendation of the advisory committee to redefine the metre is accepted in 1960 by the General Conference of Weights and Measures, the procedure initiated in 1927 will be taken to its logical conclusion and there will be a further gain in accuracy by virtue of the superiority of the chosen krypton-86 radiation over the provisional cadmium-red radiation. The metre will then be securely anchored to a natural phenomenon and freed from the frailties of an artificial standard. A similar benefit will be conferred upon the yard, and at the same time the present difference of nearly 5 parts in a million between the British and American yards eliminated, if the proposal now under discussion to define each as being exactly equal to 0·9144 metre is adopted. That there will be gains when all this has come to pass is patent and the metrologist will, with justice, be able to congratulate himself on having put this room of his house in nice order.

But can the engineer look to these latest developments for still further improvement in his standards? The question is pertinent in view of the news that, in America, a project to manufacture and measure slip gauges to 10^{-7} inch is actively under way. Is this realistic? At present, the sizes of the highest grade slip gauges are established by interferometry to an accuracy of $\pm 10^{-6}$ inch for lengths up to 1 inch. This is possible because these gauges have the requisite quality of surface finish, flatness, and parallelism. For measurement, they are wrung to a flat plate of near-optical finish and the size determined includes the thickness of the wringing film which is, on average, 2 to 3×10^{-7} inch. A correction is required on account of the phase loss experienced when light is reflected from a steel surface; this must be determined by measurement and may range from 1 to 3×10^{-6} inch. Nevertheless, by very patient research, it may be possible, doubtful though it may seem, to make gauges so precise in geometrical finish and with surfaces of such quality as to permit of their measurement to an accuracy of the order of 5 to 10 molecular diameters.

But will this advance, if accomplished, really benefit the engineer? After all, machines are not built solely of rectangular parallelepipeds. Rotary parts call for cylindrical fits, involving the measurement of holes and shafts. Today, 10^{-5} inch is the order of accuracy that can be achieved in the measurement of a cylindrical plug or a standard ring, though the reference, the slip gauge, is known to 10^{-6} inch. Surely progress would be more realistic if a substantial improvement could be effected in the transfer from plane to cylindrical standards. What effort is being made in this direction is a question which seems to be well worth asking.

If the thickness of this page of DISCOVERY is taken to represent 10^{-7} inch, the thickness of the average human hair would be represented by a pile about 80 inches high comprising some 20,000 pages!

ELECTRONIC MUSIC

In 1951 an international vacation course in modern music was established at Darmstadt, where Dr Mayer-Eppler of the University of Bonn, put forward the theory that it should be possible to create an entirely new sort of music, building up from soundwaves made by an electronic frequency-generator. The idea was taken up by Herbert Eimer, the composer, at the Cologne Radio Station, where a series of experiments were made to choose suitable apparatus and design, and to establish practical means of composition in this medium. Since then the main body of experimental work has been carried out in Cologne; the radio stations at Milan and Tokyo, however, have also constructed special studios for this new medium, and it has been broadcast from many other radio stations, including the BBC, Third Programme. At Kranichsteiner Musikinstitut, Darmstadt, a studio working independently of radio stations has been equipped this year with apparatus for producing electronic music under the direction of Hermann Heiss.

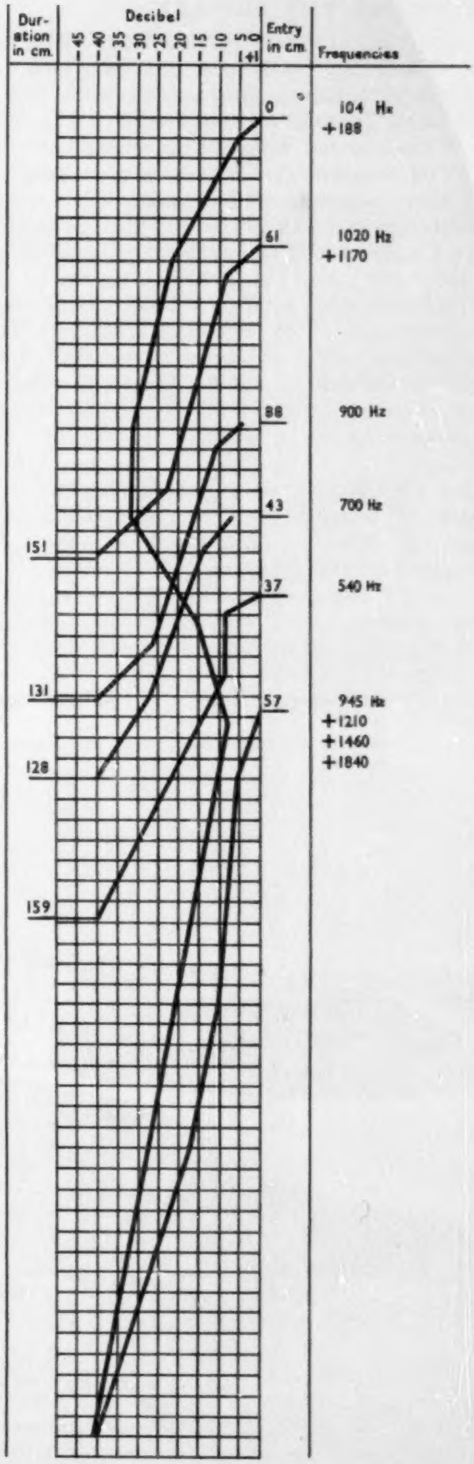
Electronic music is made by two types of frequency-generator. The first type is a simple oscillator which will produce a sine-wave at any audible frequency with control

of strength from zero to minus fifty decibels; the second type is called a white-tone generator, which produces a noise compounded of the whole "spectrum" of overtones belonging to any fundamental note. The sound of the first type of wave is a thin wail, without harmonics, and that of the second is a rushing sound like an escape of steam. The latter can be modified by means of filters in the circuit which will cut out various unwanted overtones according to the requirements of the composer (limiting these to a narrow band if desired) while the other (sine-wave) type is treated in just the opposite way, by adding other sine-waves to the original one, thus building up a tonal structure. Further construction may be carried out by the use of multiplier, ring-modulator, wobble-generator, echo chamber, or the steel-plate echo device. Addition and multiplication of the sounds can be done electronically, the whole can be reversed, slowed down or quickened (with corresponding variations in pitch), reduced or strengthened in volume.

All these effects are planned in the mind of the composer, written down in the form of a graph, made on the apparatus according to the instructions shown on the graph, and recorded on tape. The recorded tape is therefore the composition completed and ready for performance either by radio or to an audience gathered in a room. The new medium does not sound at all like the conventional, instrumental music we have been accustomed to hearing; electronic music need follow no conventional scale, nor accept any tone-colours not designed and made by the planner; the apparatus will make soundwaves at any frequency and in any order or combination known to mathematics. The composer's object is not to imitate music already possible by the older means but to create a new music. He strives to provide a scheme of sounds which has a mathematical basis comprehensible as an aural pattern, knowing that if the mind of the listener can learn to understand this pattern the result will be acceptable as an art-form.

All this may look very unmusical on paper, but it must be understood that previous to this invention, certain modern composers had been experimenting with music intended to be played quite objectively, without emotional stresses or other subjective conditioning, and some of the fascination of electronic music in the early stages of experiment was in the hope that at last composers could produce absolutely pure music. After six years of experiment, however, it is now becoming obvious that aesthetic and emotional associations cannot be eliminated; the hearer will himself supply a subjective element to the mental effect he receives.

Besides these attempts to create abstract music, there have been experiments in the use of electronic music for background noises to plays and films. In particular, the unearthly character of much of it is suitable for supernatural stage situations. Peter Brook has experimented in this way. Among composers on the Continent who have composed electronic music are Herbert Eimer, Karlheintz Stockhausen, Henri Posseur, Hermann Heiss, Bruno Moderna, Luciano Berio, Ernst Krenek, Gottfried M. König, Giselher Klebe, Bengt Hambraeus, and in Japan two composers working in collaboration—Makoto Moroe and Toshiro Mayuzumi.



A graph of an electronic Interval Signal. This is the Darmstadt method of notation for electronic music, reproduced here by permission of the composer, Hermann Heiss. Duration of sound is read vertically, and intensity is read horizontally. The pitch is indicated by the frequency numbers on the extreme right. Other centres such as Cologne use graphs from which duration is read across the page, and intensity is read vertically.

OIL UNDER THE SAHARA

"The desert within a desert" is what Arabs call the East and West "Grand Ergs"—vast areas of shifting sand dunes in the depths of the Sahara. Between them lie the rock-strewn wastes of the Tademait plateau. Over 60,000 sq. miles (the area of England and Wales) of this inhospitable terrain a French oil company (the CPA) holds under permit for oil exploration. Since the 1953–4 season it has spent some £14 million on its search for oil.

The headquarters of the operation are at El Golea, outside the permit areas to the north. To the west and east lie the Timimoun oasis and Fort Flatters—minor centres of administration, with hospitals and a source of labour. For eight or nine months of the year, until the heat of full summer makes conditions in the desert intolerable, parties of European technologists and their assistants traverse the region, carrying out a systematic survey of geological conditions.

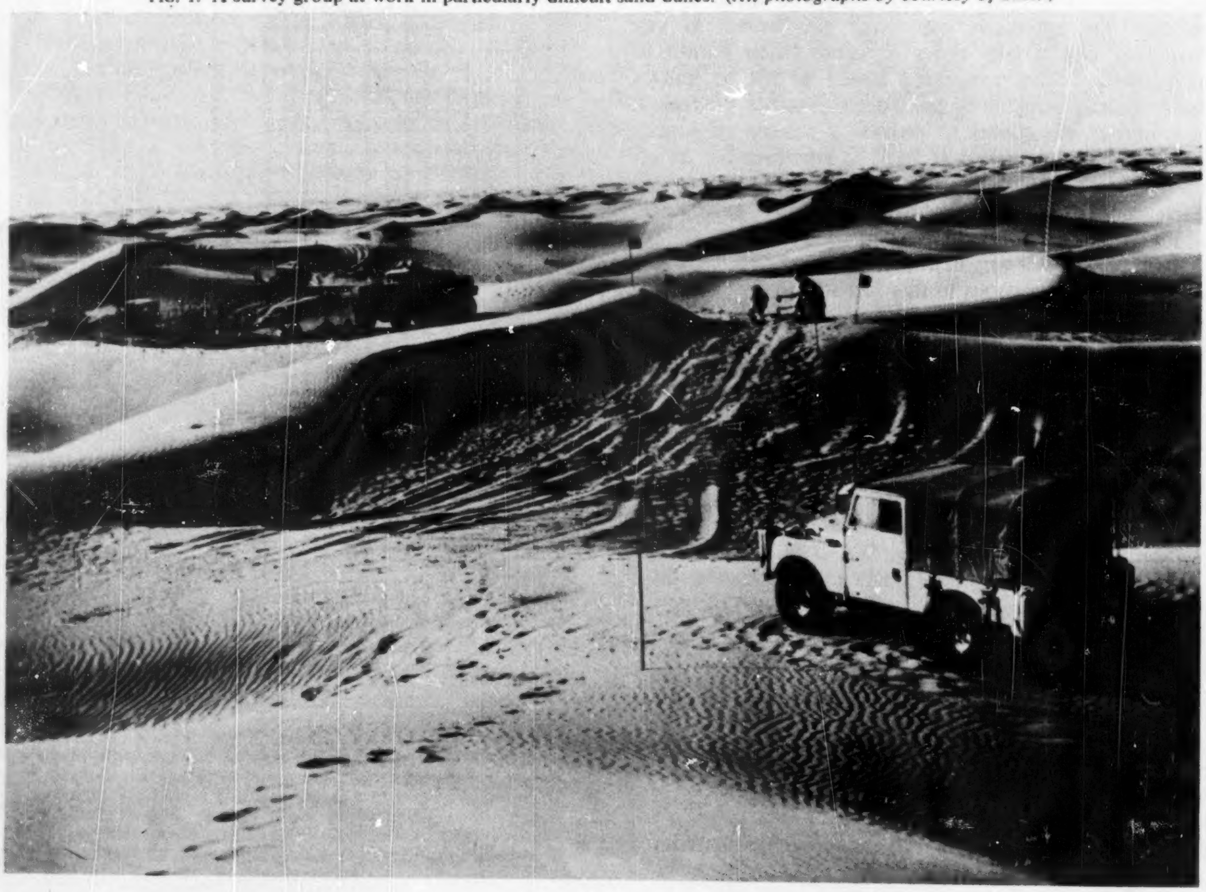
After the initial aerial survey, the geological parties explored the terrain collecting surface data. Two types of geophysical survey are now in hand. First, gravimetric, which involves the measurement of minute differences in the force of gravity at different locations. More than 60,000 separate readings have already been taken from which it is possible to determine the form of the rock structure which may be favourable to the accumulation of oil. Secondly seismic, whereby the repercussions of artificial earthquake shocks are charted in such a way as to indicate the contours of different underground strata.

Survey teams may comprise up to ten technologists, plus assistants, mechanics, and drivers, and up to 100 local labourers. They travel by air, Land-Rover, camel, or on foot. For the most part they must live in tents which are moved from site to site as necessary, together with all the scientific equipment, supplies, and the very large quantities of water which are essential to life in that severe countryside.

In the wake of the survey parties come the exploration drilling crews who have sunk twenty-seven wells with no more success than a few traces of dry gas in one or two of the permit areas. The drilling crews lead a more settled life than the survey parties. They work, however, all the year round, doing their eight-hour shift on the rig even in the full heat of summer when the thermometer reaches 120°F in the shade.

The administrative difficulties of mounting an operation employing many hundreds of men in this empty quarter where no civilised amenities previously existed, are tremendous. One thousand one hundred miles of new roads and tracks have had to be constructed to move the heavy drilling equipment from site to site, and existing roads have had to be repaired. No fewer than twenty-eight airstrips have been created at each of the well sites and at the main administrative centres so that equipment and supplies can be flown in regularly. As surface water does not exist

FIG. 1. A survey group at work in particularly difficult sand-dunes. (*All photographs by courtesy of Shell.*)



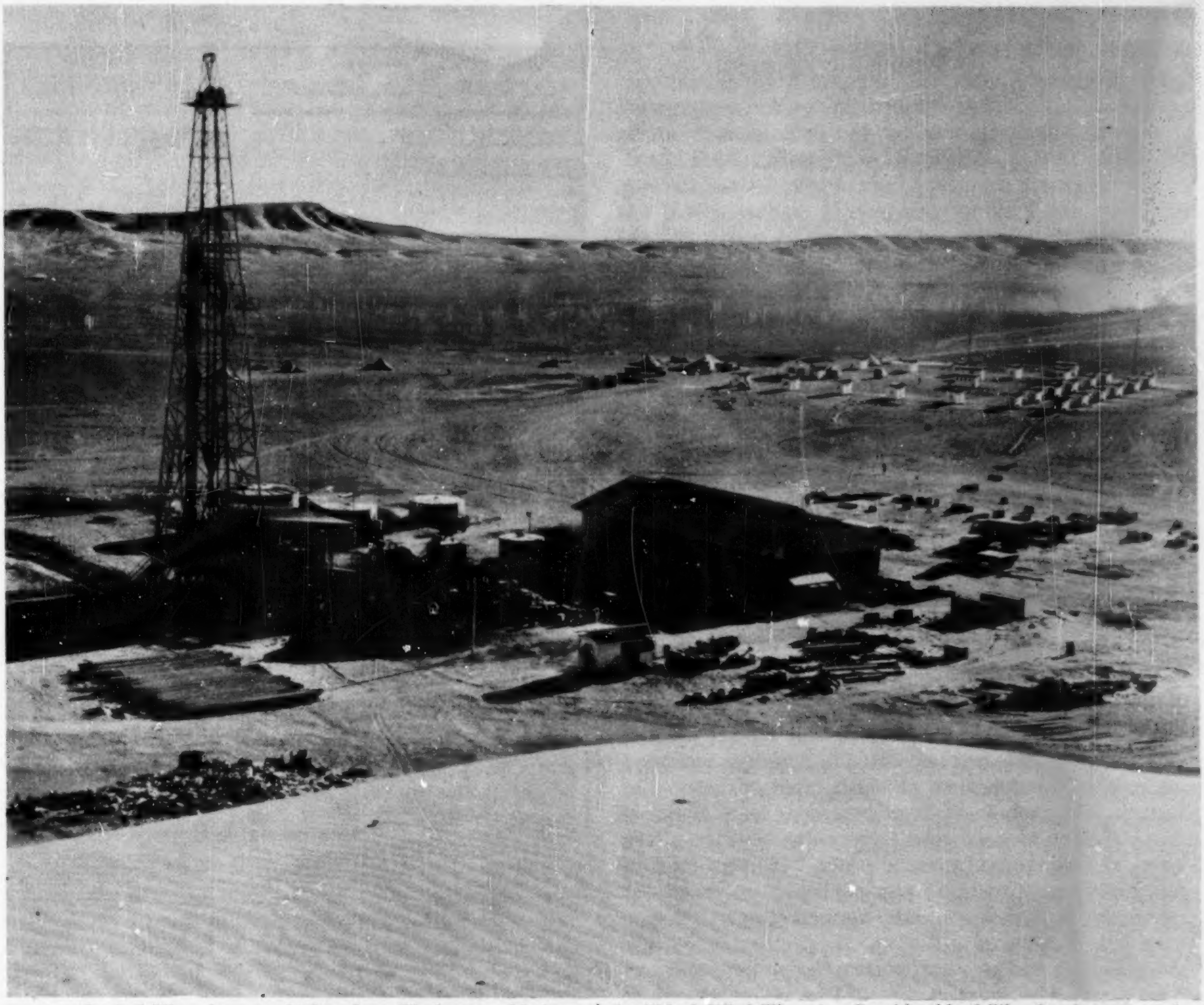


FIG. 2. A drilling site some 20 km. from Timimoun with (*centre*) the "Ideal 50" drilling rig. Considerable drilling has been carried out in this neighbourhood which is over 900 km. south of Algiers. Geophysical survey has been followed by drilling.

except in the oasis, and as a drilling rig may well use some 17,500 gallons a day, the early geological wells have had to be converted into water wells or new water wells sunk to allow tank lorries to provide a regular supply to the drilling sites.

The regular trips and the less predictable wanderings of the exploration parties in their Land-Rovers cannot take place without careful planning and supervision, as a serious breakdown in the desert wastes might otherwise mean rapid starvation and death by thirst. All journeys are routed and scheduled and every party is in short-wave radio communication with headquarters.

To the north-east, French interests have made a promising discovery of oil at Harri Messaoud, while even farther south and east the Compagnie de Recherches et d'Exploitation de Pétrole au Sahara is developing a series of small oil structures at Edjele and Tiguentourine. In the course of time the problem of transporting the oil from these new fields must be solved by the construction of pipelines to some point or points on the coast. Meanwhile, the exploration parties and drilling crews of the CPA, doggedly pursue their search. The problem of transport will be solved if the men on the spot find oil.

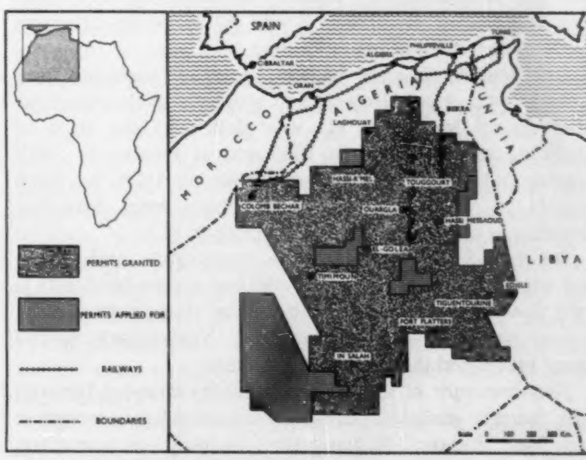


FIG. 3. A sketch map showing exploration of various companies.

OSCAR MINKOWSKI (1858–1931)

Oskar Minkowski, who was born one hundred years ago on January 13, 1858, at Alexoten in the Russian province of Kovno, paved the way for the final triumph in the history of diabetes—the discovery of insulin. After attending the *Gymnasium* at Königsberg, he studied medicine at Strasbourg and Freiburg, and in 1881 graduated M.D. At Königsberg he had the good fortune to work with the brilliant clinician and pathologist, Bernard Naunyn, who devoted almost his whole life to the study of metabolism in diabetes and in diseases of the liver and pancreas. Greatly impressed with his young assistant's "freedom, clarity, and mobility of mind" and manual dexterity, Naunyn invited him to accompany him to Strasbourg when he succeeded Adolf Kussmaul in the chair of clinical medicine.

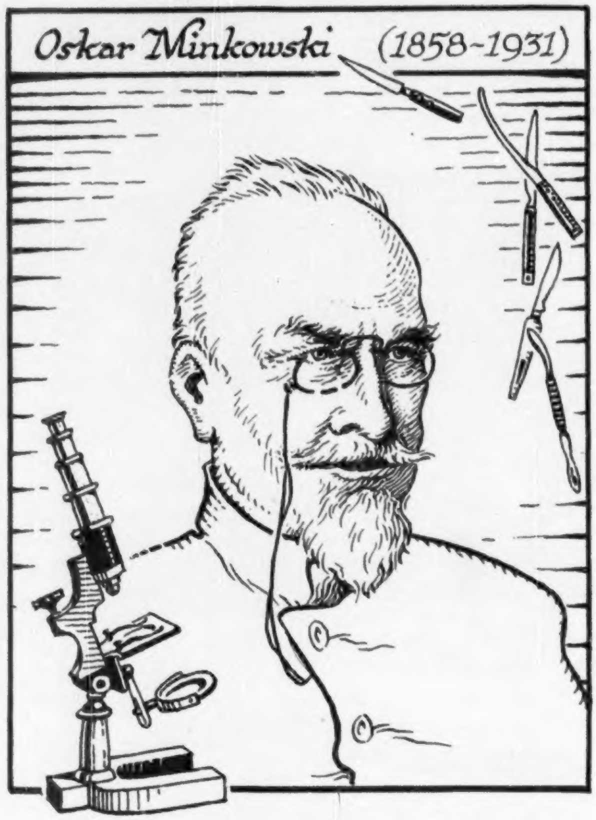
One of Minkowski's colleagues at Strasbourg was Josef, Freiherr von Mering, the professor of pharmacology, with whom he had many a discussion on the significance of sugar in the urine. Deciding to put their argument to the test of experiment, Minkowski in 1889 extirpated the pancreas of a dog, von Mering acting as his assistant. When the latter returned to the city after twenty-four hours' absence, he was told that the dog had severe diabetes with 5% sugar in the urine. The experiment was repeated on other dogs, all of whom developed insatiable thirst, glycosuria, hyperglycaemia, ketosis, and typical diabetic cachexia, thus demonstrating that the pancreas secretes a substance, lack or deficiency of which, causes diabetes. The pancreas had previously been regarded as a gland of external secretion concerned only with digestion. Von Mering and Minkowski's classic paper, "Diabetes mellitus nach Pankreasexstirpation" was published in *Archiv für experimentelle Pathologie und Pharmakologie*, 1890, vol. 26, pp. 371–87.

Minkowski's earliest contribution to our knowledge of diabetes was his detection in 1884 of the presence of β-oxybutyric acid in the urine of diabetic patients and his suggestion that diabetic coma was due to acid intoxication of the blood. Among his more important studies in other fields may be mentioned the first description in 1900 of haemolytic jaundice. He was also the first definitely to note the association of pituitary enlargement with acromegaly. During the 1914–18 war he made an extensive study of the effects of gas-poisoning.

In 1900 Minkowski became chief physician at the Cologne Municipal Hospital and professor at the Academy of Practical Medicine. He was elected to the chair of medicine at Greifswald in 1905 and at Breslau in 1909. Having retired as emeritus professor in 1926, he lived quietly at Wiesbaden until his death from bronchopneumonia on June 18, 1931, at the age of 74.

Distinguished and youthful in appearance, and simple and modest in nature, Minkowski had a fine head with a lofty forehead and twinkling eyes that shone from behind a pince-nez attached to a black cord. Neat moustache and beard completed the professorial picture.

The discovery of insulin has radically changed the outlook towards diabetes, previously regarded as an incurable and fatal disease. Without the discovery of pancreatic diabetes insulin would not have seen the light. The name of Oscar Minkowski is assured of an honoured place on the roll of those whose discoveries have in perpetuity benefited mankind.



Minkowski, who removed the pancreas of a dog and thus established the cause of diabetes.

THE BIOLOGICAL PRODUCTIVITY OF BRITAIN

Although the Malthusian spectre of world starvation has receded somewhat of recent years, biologists are well aware that it lurks not far ahead. The population of the world continues to expand by leaps and bounds and it is becoming a question of how long improvements in agricultural techniques will be able to keep pace with the rapidly increasing demand for food. Consequently, the biological productivity of Britain, which formed the subject of the Institute of Biology's symposium for 1957, is of more than mere academic interest.

The symposium, held in the Lecture Hall of the Royal Geographical Society on October 4 and 5, was opened by Lord St Aldwyn, Parliamentary Secretary to the Ministry of Agriculture, Fisheries, and Food. It comprised thirteen papers, which were followed by discussions on various aspects of land-use, animal and crop production, forestry, fresh-water fisheries, and so on.

In the earlier papers it became clearly apparent that in this country production is often limited by economic factors which are quite distinct from biological considerations. For example, Dr H. G. Sanders (Ministry of Agriculture) pointed out that if all possibilities were fully

exploited this country could probably feed itself entirely. This, however, would involve raising the labour force unreasonably and would result in a peasant type of farming with a seriously lowered standard of living. It would also mean ignoring the law of diminishing returns which is ever present in the farmer's mind. For him the question is not how much can be produced, but what level of production is the most profitable. It would also seriously undermine our trade with the Commonwealth.

Again, Dr G. H. Bell (Plant Breeding Institute, Cambridge) indicated that there are many ways in which the productivity of crops can be improved; for example, by the development of new varieties which make it possible to introduce a crop to an area where it has not been grown before, or by the selection of disease-resistant strains. But the pattern of agriculture within the natural setting is always affected by the hard facts of economics, and plant breeding policy must equally be planned within the economic framework, not only of the present but also of future trends. Although crop production will respond to new demands for many years yet, the problem must eventually be related to the increasing population of the world.

That this is far from so at present was clear from the paper of Prof. M. McG. Cooper (King's College, Newcastle), who pointed out that in the early spring there was such a glut of eggs in this country that some of the surplus had to be exported to Western Germany at a price so far below the cost of production that there were justified complaints of dumping from Denmark. At the same time, the retail price of eggs in Britain barely exceeded the subsidy to maintain the guaranteed price. The recent expansion of our animal industries is maintained only by subsidies at a rate that the taxpayer may some day consider excessive.

The dairy cow, if properly managed, is by far the most efficient farm animal in converting food into energy and protein. The laying hen and pig come next, followed by sheep and bullocks. But pigs and hens eat much food that could otherwise be used directly by man. On the other hand, millions of acres of upland would have no more than an amenity value if it were not for the hardy breeds of sheep and cattle that are adapted to rigorous conditions. If existing knowledge were applied, all our requirements of meat and eggs could be produced without affecting the crops needed for human consumption, for British livestock, as well as the land that supports them, are performing well below their potential.

Efficiency could easily be improved by early weaning and by the use of silage as food in place of expensive imported grain. Just as the buck rake and forage harvester have reduced the labour of ensiling, so self-feeding at the face of a clamp promises to reduce the labour involved in feeding to a trifling task. The immediate problem is one of providing adequate agricultural education.

From the point of view of forestry, whereas France and Germany have a balanced economy with 0·62 and 0·44 acre of forest per head of population, respectively, in Britain the figure is 0·07. The aim of the Forestry Commission, as outlined by Mr M. V. Laurie (Forestry Research Station, Farnham) is to have 5 million acres of *productive* forest in fifty years. This should produce one-third of our requirements and also provide a strategic reserve. At present there is an excess of mature trees which will continue to provide limited yields for the next twenty or thirty years, after which there will be a long period of shortage until the young plantations raised during the last two or three decades come into being. By A.D. 2030, production should be going really well.

As Dr J. D. Ovington (Merlewood Research Station, Nature Conservancy) pointed out, however, the present emphasis is on providing straight boles suitable for pit-props and telegraph poles: requirements may well be different in the future. Forestry is a most efficient form of land use, but at present only a small proportion of the organic matter produced by trees is utilised.

Lack of information regarding the importance of water control for increased crop production was emphasised by Dr H. L. Penman (Rothamsted Experimental Station, Harpenden, Herts), who said that 2½ million acres could benefit from renewed drainage works. The need for research was also stressed by Prof. J. B. Cragg (Department of Zoology, University of Durham), who advocated a policy of multi-purpose use for the uplands, with trees, sheep, deer, cattle, game, and crop production used as ecological tools to restore balance to the herbage of the hills.

The symposium concluded with a stimulating and controversial paper by Mr N. W. Pirie, F.R.S. (Rothamsted Experimental Station, Harpenden), who pointed out that there are no known or probable foods that give more energy per gram than fats. So whatever success we may have in making new types, the nightmare of a meal degenerating into the swallowing of a few pills every day is baseless.

Nevertheless, we eat more than 8 million tons of dry matter each year and metabolise a considerable amount of energy. Indeed, we are running at nearly 6500 megawatts, which is approximately the same as that to come, by 1965, from the twelve proposed nuclear power-stations!

From these power-stations some 20,000 megawatts in the form of hot water are likely to be wasted annually. This would be sufficient to warm some thirty-five square miles of glasshouse—about twice the area at present under glass. Expensive installations of pipes would no doubt be necessary for this to be made available, but even so, it seems incredible to the writer that the wastage envisaged can really be economic!

Alcohol is the only one of the substances cheaply synthesised in bulk which is already a familiar food, and the primary source of food material is likely to continue to be the higher plants. In the future, however, instead of deciding what conventional foodstuff is wanted and then organising agriculture to produce it, consideration may well be given to what plant a particular area can produce most abundantly. This will then be changed by means of biochemical engineering into some edible form such as leaf protein, at present a laboratory curiosity rather than an article of commerce. In this way the enormous loss that occurs when vegetable matter is converted into meat by farm animals will be obviated.

The proceedings of the Symposium will be published in due course by the Institute of Biology.

DIAMOND: FICTION, FANCY AND FACT

S. TOLANSKY, F.R.S.
Professor of Physics, London University

There is no single object of modern scientific interest which has so long and romantic a history as diamond. The earliest written record about diamond appears to be that in the Bible where it is mentioned no less than four times. The old rabbis always regarded as diamond the *Jahalom*, the third stone in the second row of the twelve precious stones set into the breastplate of the High Priest. Since each stone was engraved with a letter representing one of the twelve tribes, much doubt has been cast on this interpretation of Jahalom, as it is virtually certain that no ancient craftsman knew how to engrave a diamond. Yet in fact this is not a sound objection, for it has of late been firmly established that many diamonds among those now being mined have, on their faces, ruts or "fosse" markings (due either to etch or to growth) many of which indeed resemble ancient Hebrew letters. That a suitably marked diamond could have been found and used is well within the bounds of probability. Furthermore, in Jeremiah, we read "The sin of Judah is written with a pen of iron, with the point of a diamond." The implication is clearly that a diamond point can engrave an imperishable record, doubtless on hard stone or metal. So we see that even in biblical times that typical special characteristic of diamond, its hardness, is known.

PLINY'S VIEWS

Diamond is first mentioned in Greek records in about the third century B.C., as Adamis ("the unsubduable"), being primarily so named because of both its hardness and its resistance to fire. It is, however, to Pliny (died A.D. 79) that we owe most of our knowledge of the lore of early times concerning diamond. There is evidence that Pliny's comments took root in China, influencing Chinese mythology about diamond. Although it is almost quite certain that all early diamonds came from India, Pliny's account of their source deserves repeating. It is suspected that this tale goes back to the 4th century B.C., and it is highly reminiscent of the later familiar Sinbad the Sailor story. The diamonds, says Pliny, occur only in one deep, very inaccessible valley. The natives throw carrion flesh into this valley, the diamonds adhere; eagles swoop down and carry off the flesh to their mountain nests; and the diamond gatherers collect from the nest.

It is more than probable that such stories could be deliberately circulated to hide the real sources, but strangely enough, this myth is paralleled by an unusual current reality. For it is a definite fact that around the deep diamond diggings in South Africa the crops of the fowls which wander locally over the worked-out heaps of rubble often contain small diamonds. It seems that the local chickens have an eye for a glistening pebble!

Pliny, like every ancient commentator on diamond, emphasises its indestructibility and further, ascribes it only to kings because of its great value. He is the first to record the legend that if a diamond is placed on an anvil and struck with a hammer, the hammer will be damaged but *not* the diamond. There is more than an element of truth in this. Indeed, if a diamond is squeezed in a vice, it will in fact penetrate the iron jaws and damage the vice, a fact which was recorded as far back as in the 13th century by Ibn Mansur. It is amusing to recall that unscrupulous dealers in recent times, when buying from simple diggers during diamond rush periods, fostered this ancient myth to their advantage. They spread the story that a real diamond when struck with a hammer remains intact but damages the hammer, hence if a stone when offered for sale broke up under such a treatment, it was clearly not a diamond. Many a simple digger subjected his precious find to this test and left disappointed when his stone (a real diamond of course) shattered into fragments. The dealer was content to collect the pieces, secured for nothing by his guile. The point of the story is that although the diamond is very hard, it is at the same time quite brittle, and in fact many a fine gemstone has had its corners chipped merely by a rough handling with tweezers.

Pliny records, too, for the first time, the famous myth, that the "unsubduable" can be easily broken by blows, provided the diamond is first dipped into fresh, warm goat's blood! It seems clear to me that this is hiding the fact that the art of cleavage was really known to some and, of course, as was common with such arts at such times, was suitably disguised. By the time Pliny's views had spread over China there was some modification, for Chinese records state that while a blow from a metal hammer on diamond damages the hammer, on the contrary a blow from a ram's horn shatters the diamond. The Chinese, more realistic, replaced the blood by a horn.

CLEAVAGE OF DIAMOND

That a diamond can be cleaved was known to Theophilus in the 10th century A.D. and there is indirect evidence that this was known earlier in India, but how much earlier can only be conjectured. The earliest forms of diamond were certainly used in natural form, the transparent octahedron (the "glassy" of the modern gem trade) being attractive enough without further working; they were certainly not polished, although they may have been cleaved. There are numerous successive European records about the art of cleaving of diamond, notably de Boot (1604). Robert Boyle in 1672 says that he was shown how to cleave diamond by a jeweller. At the same time he makes several acute observations on diamond; he records, for the first time, seeing with his microscope the small triangular growth features which we now call trigons, and states that at high temperatures the diamond dissipates into acrid vapours. It remained for Lavoiser to establish that the diamond burns away to carbon dioxide.

With regard to the goat's blood story, it is worth recording that in some diamonds found occasionally in South Africa, there can be considerable structural weakening due to an inclusion, indeed there is already incipient cleavage. Such a diamond cleaves so easily that even the heat of the hand induces fracture. With such a stone, doubtless the heat of the goat's blood would have helped.

Myths about cleavage are by no means confined to ancient times. Among Australian and South African diggers arose the firm belief (again fostered by dealers) that smoky areas on otherwise clear stones invariably led to explosion and shatter. The crafty digger, on finding a stone with a smoky corner, would keep it warm in his mouth and rush it off to the dealer; retreating after the sale, in great glee, confident that by the morrow it would shatter in the dealer's safe into a thousand pieces. Of course if the dealer saw the smoky part, the game was up and the price paid ridiculously small. In fact it is on record at de Beers, that despite the handling of millions of stones, never has one burst. On the contrary, such traditionally suspected smoky stones have been subject to heat or to a vacuum, to emerge unscathed. Some diamonds exhibit microscopic bubbles of what might well be liquid carbon dioxide under pressure, but even these do not oblige by exploding when heated. The French traveller Tavernier stated explicitly in 1679 that the Indians knew the art of cleaving, but by this time it was also well known in Europe. Beyond this, he has nothing to add, such as how long the Indians really had this art at their command.

THE POLISHING OF DIAMOND

The whole position with regard to the working and shaping of diamond was radically changed by the discovery that diamond facets could be polished with crushed diamond powder. The real origin of this discovery is wrapped in mystery and secrecy. It certainly appears to be a European invention. It has been claimed that both in Paris and in Nuremberg the polishing art was secretly practised in the 13th century. What is certain is that fully matured polishing techniques were operating in the Netherlands during the 15th century. Traditionally Berghem (1476) is given the credit for inventing the polishing of diamond with diamond dust, but it seems evident that it might well have been long known. Benvenuto Cellini described in 1568 the current method then in use, and this might well be a description of modern practice. For apart from replacing the treadle worked by manpower with the rotating polishing discs of machines, it is a matter of real astonishment that our modern polishing methods of holding the diamond and of treating it are virtually identical with those known to be in use 400 years ago. The accompanying print (Fig. 1), published by the Frenchman Felibien in 1676, shows the technical equipment used in the 17th century for diamond polishing. There is the familiar horizontal grinding wheel (D), spinning about a vertical axis. The diamond is held in a dop and tang (3), precisely of the kind still in use. Both the cleaver's box (A) and the bruting sticks (B) are still used today. On the shelf at the left is a pestle and mortar for pounding diamond splinters into grinding powder. Replace the hand drive by a small electric motor and any modern diamond polisher craftsman would consider he was looking at the tools in a contemporary polishing shop. Of course as yet, diamond sawing had not been invented, this had to wait until the late 19th century. This already points to the fact that the 15th- and 16th-century techniques were fully matured and therefore probably long established. I see no reason to doubt the conjecture that polishing was already employed in the 13th century.

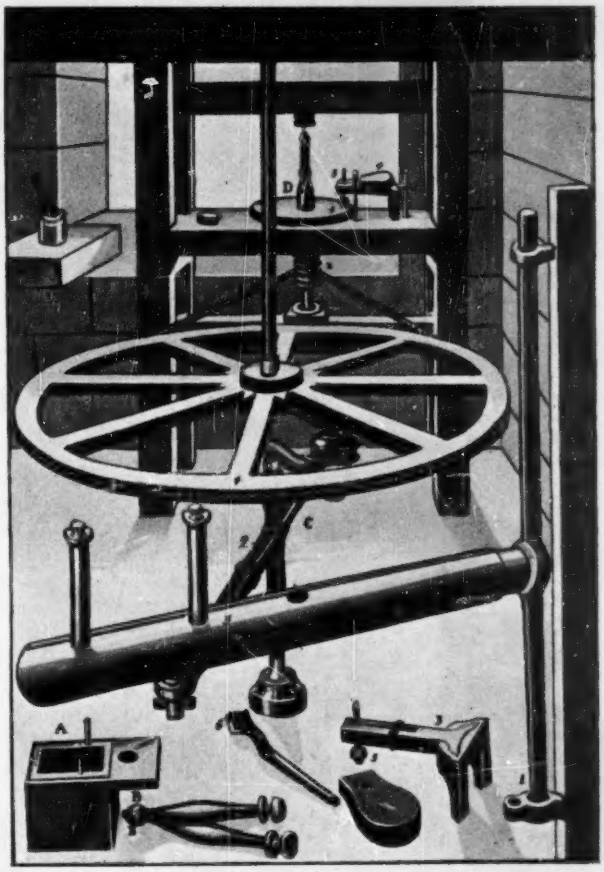


FIG. 1.

The fact that diamond dust polishes diamond is already enshrined in the folk-saying "diamond cuts diamond". The reason for this is of course that diamond hardness varies in different crystallographic directions. Since some directions are much harder than others, crushed powder always contains sufficient particles oriented in hard directions to permit polishing in the softer directions. One of the traditional secrets was the knowledge of what are the softer directions, the grain, as the polisher calls these. Practically nothing will induce an experienced polisher to attempt to polish across the grain. I have asked for such to be done for scientific purposes, but polishers invariably regard the request as an example of mild lunacy, or eccentricity at the very least.

It seems fairly certain that some diamonds are in fact rather harder than others, for diamond is a raw material with a range of physical properties. Australian and Brazilian stones are reputed to be very hard and here again the dealers have been actively myth-making. In New South Wales the story was spread that locally mined diamonds were too hard to cut and polish. Once this view was accepted low prices were offered. Such diamonds can of course always be polished by any kind of diamond dust. All diamond polishing is a slow, time-consuming business even with the best of equipment. The stone under polish is pressed against a rapidly rotating wheel and oil-impregnated diamond dust used as the grinding material. Light pressure is essential otherwise the diamond scores, burns,

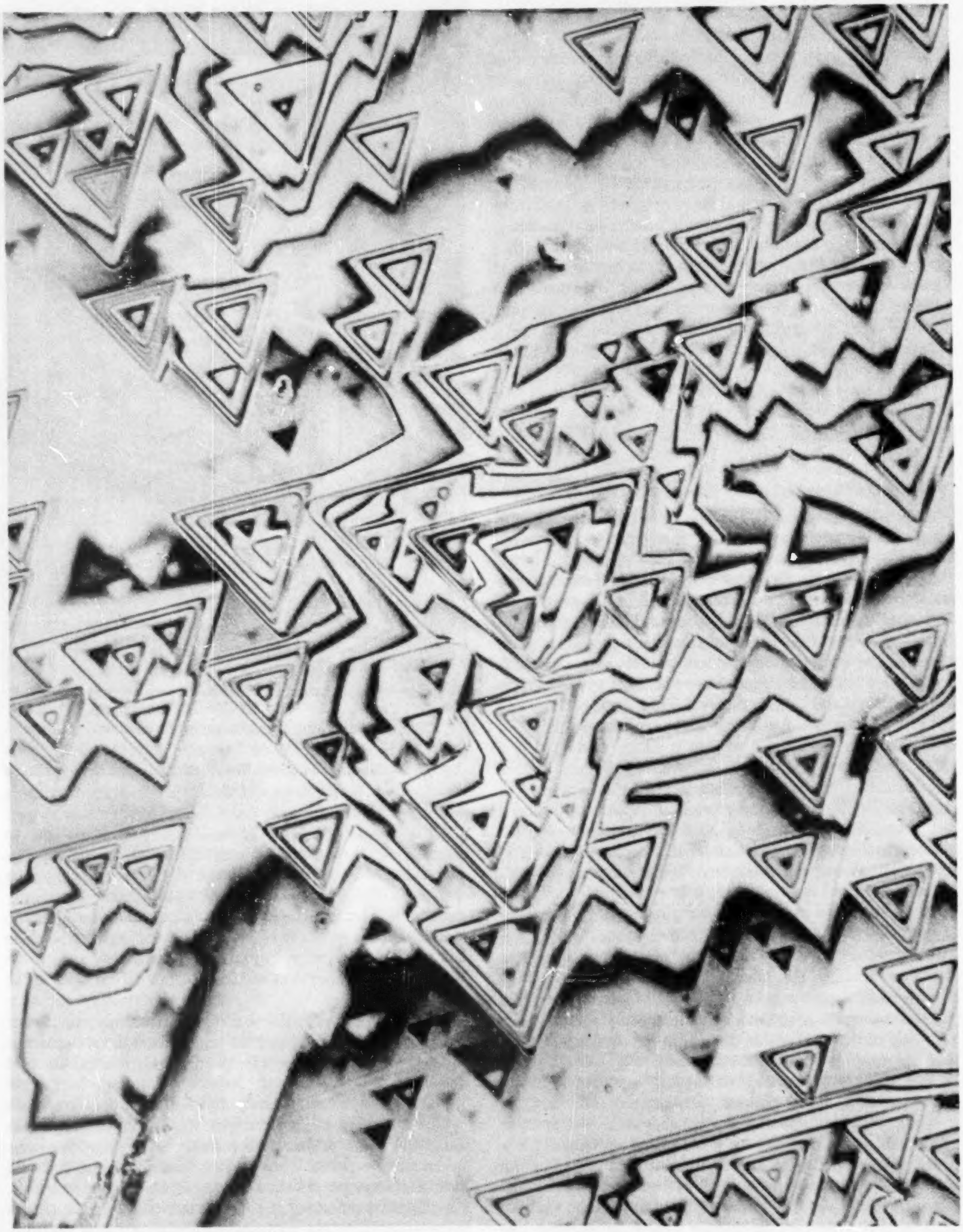


FIG. 2. Interferometric contour pattern of Trigons.

and blackens through local conversion into graphite. A large stone can take some months to prepare; the famous Pitt diamond took two years to polish.

DIAMOND SOURCES

The history of the sources of diamond is of interest. Up to the 18th century India appears to have been the sole source of supply. The mining was effectively surface working, alluvial deposits being the source. These deposits are now largely worked out. Brazil became an important producer from 1727, but apart from the finding of a secondary source in the Urals in 1829, the next important field was that found in Australia in 1852. Then in the year 1867 the child of a Boer farmer picked up a bright pebble on a South African farm, it was identified as a diamond, and so began the immense modern South African fields. Together with the Congo these produce well over 90% of current world consumption, at an annual value of some £60 million.

One most unusual reputed source of small diamonds was recorded by Crookes, who says that Friedel, Moissan, and also himself independently found both black and transparent diamonds in the meteoric iron of the great meteorite at Cañon Diablo, Arizona. Perhaps the numerous meteoric craters on the moon will also contain diamond.

There has been endless theorising over the genesis of diamond, a matter not yet by any means cleared up despite the recent production of synthetic diamond in the U.S.A. Some early views are of academic interest. Newton, who incidentally detected the high refractive index, considered diamond to be "an unctuous substance coagulated". Brewster also attributed a vegetable origin to diamond. Lavoisier established that it was crystallised carbon and the chemist Liebig considered that it was formed from the slow decomposition of a fluid rich in carbon and hydrogen.

MODERN RESEARCH ON DIAMOND

Despite its antiquity, diamond is today an object which excites an enormous amount of scientific research. Indeed for a number of years an International Conference devoted purely to the Physics of Diamond has been held annually at Oxford and Cambridge Universities. This is sponsored by the diamond-producing organisations, inspired by the growing importance of diamond as a technological material. Particular activity is being devoted to such aspects as the thermal and electrical conductivities, elasticity, optical absorption, response to irradiation, X-ray crystal structure, crystallographic morphology, and surface microtopography, yet indeed this by no means exhausts modern interest in diamond. For diamond is coming into use more and more as an important technical hard material for machine tools, dies, abrasives, hard bearing surfaces, and so forth, and world consumption for industrial purposes alone has now the formidable value of some £30 million, and this grows daily.

Yet, looking back into the long history of diamond, one sees that among the numerous physical properties which have excited interest, early attention was devoted principally to hardness, refractivity, cleavage, polish, fracture, growth (structure), and even to dissolution (etch). In my laboratory during the past twelve years I have been engaged in researches (but with modern precision methods) on the very same classical interests. One particular technique which I have developed for the express purpose of studying miscrosurfaces is that called multiple beam interferometry. It is a very high precision optical procedure which ultimately gives a picture of the surface under study covered with a network of optical contour lines (fringes). One sees in fact a contour map, just as on geographical contour maps, but the optical contour lines represent height differences, each of 1/100,000th inch. The technique permits

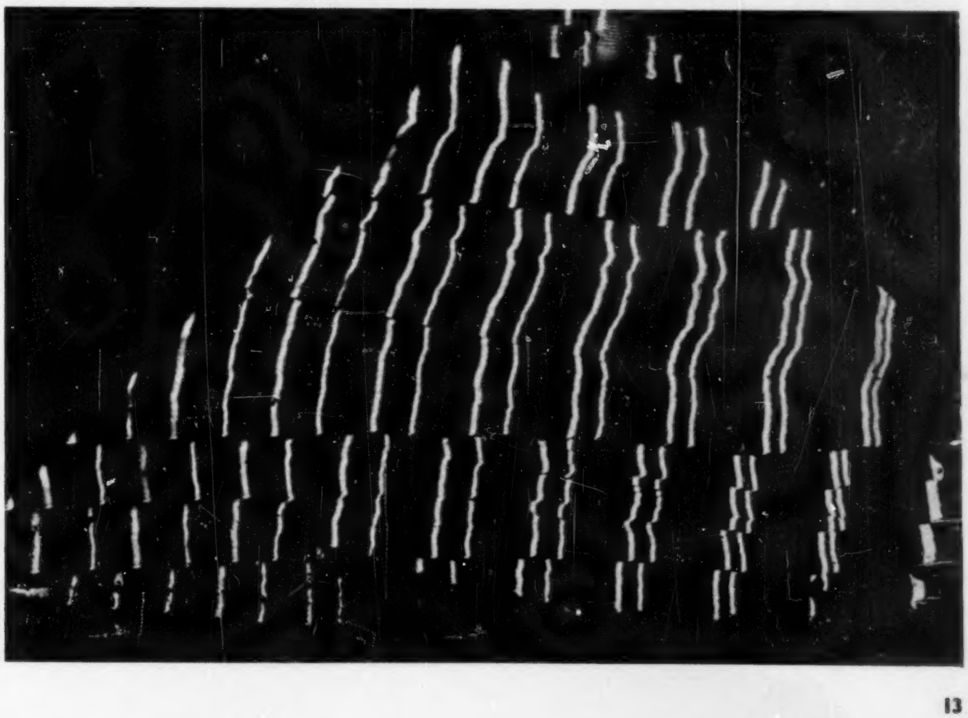
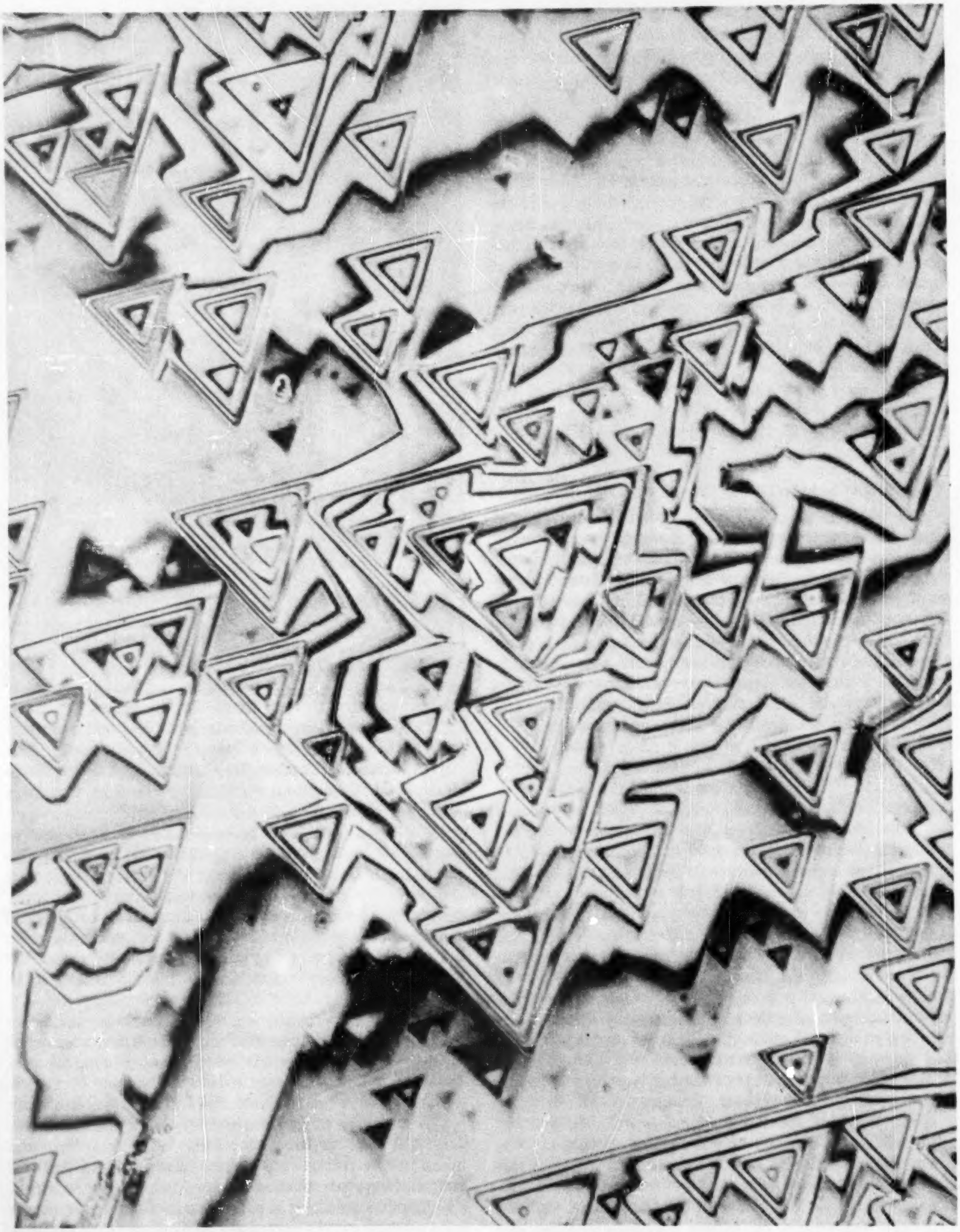


FIG. 3. Interferogram of a cleavage on a Type II Diamond.



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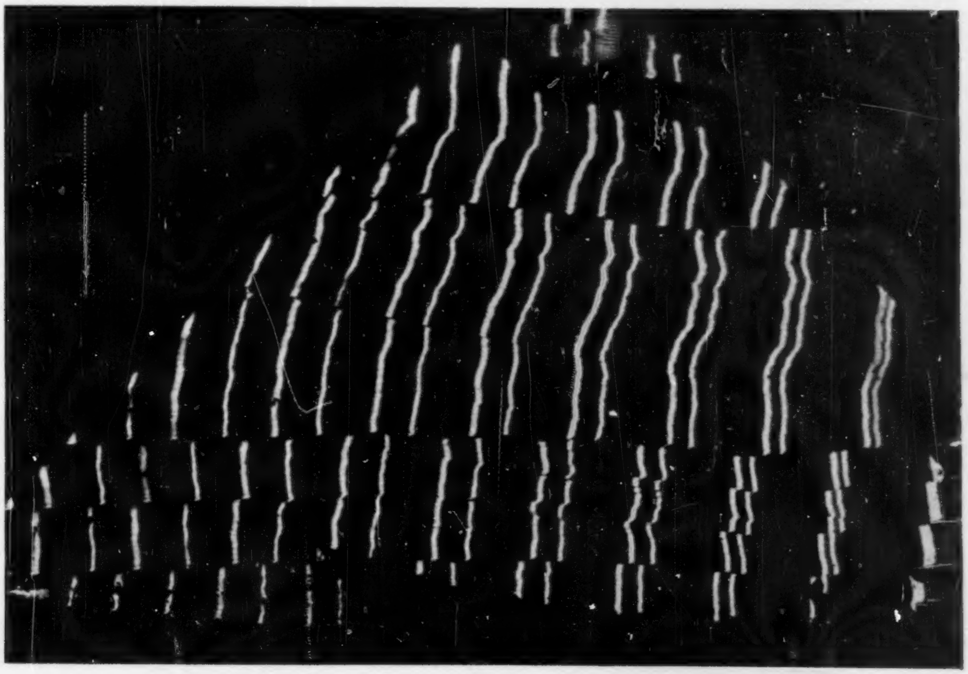


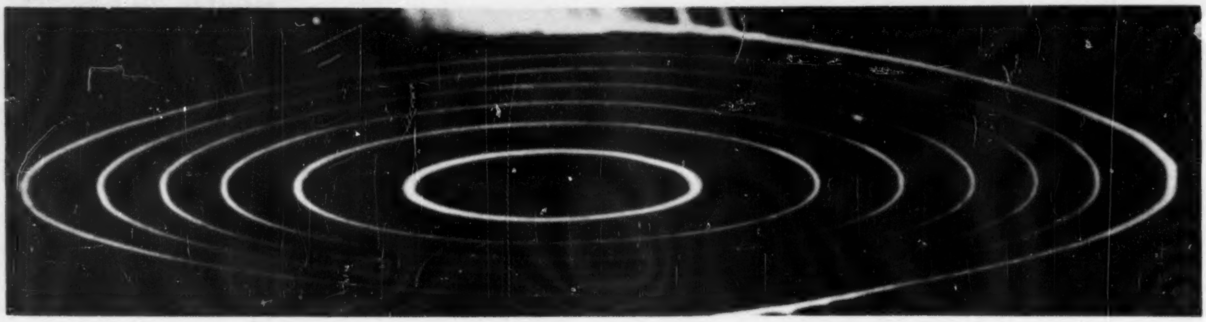


FIG. 4. Interferogram revealing the shape of abrasion rut on a diamond.

evaluation and reveals features down to as small as 1/25,000,000 inch. With such a technique much is revealed that escaped earlier observers, good as they were.

While Robert Boyle was able to report the discovery of trigons (small triangular pits; often studied by later investigators) we have been able to find out a great deal more about them with such precision methods and have obtained many beautiful interferograms which reveal a whole micro-world of topographical interest and beauty. An example is shown in Fig. 2, an interferogram given by a small region of the octahedron face of a small diamond. From an examination of some hundreds of such faces we have found trigons on every one, often far too shallow to be detected by any other technique. It is my firm belief that *all* octahedral faces of every diamond show trigons, and my equally firm conviction that trigon growth formation is essentially the way by which the diamond has grown.

Then again, I have been much concerned with the study of diamond cleavage. The classical textbooks on the scientific study of diamond, rather loosely describe diamond cleavage as "perfect". Our studies show that in comparison with many other crystals the cleavage is a very rough affair indeed. However, a curious fact emerges. It is now known that diamond occurs in at least two common forms, called conveniently Types I and II. It is considered that the difference between these is one of crystal perfection and mosaic patterning of blocks within the body of the single diamond crystal, such a block patterning arising from the accidental history of growth. I find that whereas Type I (the commoner type) cleaves crudely, yet Type II often exhibits in small local regions a highly perfect cleavage. A smoothly cleaved surface shows regularly spaced parallel interference fringes. Fig. 3 is an example of a small corner of a Type II cleavage which can be considered relatively very smooth and plane. In comparison, figuratively speaking, a Type I cleavage looks like the Alps, compared to the Hungarian plain of Type II.

It has already been mentioned that diamond polishers have for centuries had very strong prejudices and convictions as to directional hardness and to the directional resistance to polish. There is plenty of tradition, most of it absolutely sound, but little scientific data. Only now are careful studies on directional grinding rates being made, especially in the U.S.A. We have made some numerical studies on a micro-scale of this differential hardness in different directions using a technique which enables us to examine local minute regions on small faces.

With a high-speed conical wheel, fed with diamond dust, a small shallow rut (about 1/10 mm. long and, as event shows, perhaps a mere 1/1000 mm. deep) is ground on to the diamond face. The volume abraded away, that is, the dimensions of the rut, are a measure of the hardness in the direction selected, and with similar loads and grinding times, different sized ruts are secured in the different directions, giving us then a numerical measure of the directional resistance to abrasion. This is what every polisher knows qualitatively but not quantitatively. It is by means of interferometry that the volume of the rut is assessed. Fig. 4 shows a highly magnified picture of the fringe system given by such a rut. This reveals not only the shape and volume, but shows too that the internal polish is high and indicates that the edges are clean cut and free from a "pile-up" which would not be the case when abrading into metal.

Despite the great hardness of diamond, so long traditionally accepted, a most surprising observation is that it is very easy indeed to induce small artificial percussion crack marks on diamond faces, by only moderate pressures. A diamond or hard carbide ball, when pressed on to another diamond with a load of a mere few pounds, produces crystallographically oriented hexagonal-shaped ring cracks. An example is shown in Fig. 5. The crack pattern is small and the height of the ledge produced is only of the minute amount of 1/1,000,000 cm. Yet, of course, even so minute a crack becomes the nucleus of a breakdown centre when such a cracked diamond is used as a tool. By means of other techniques I have found that such percussion marks are frequent on natural diamonds brought up from the mines, and it may well be that the crushing machinery used on the ore is responsible for these cracks. They are invisible in the microscope unless developed up by special techniques.

Robert Boyle mentioned that a strongly heated diamond dissipates into acrid vapours and we have studied intensively the mechanism of etching or solution of diamond produced by hot oxygen liberated by hot oxidising agents. Attack by oxides at about 600°C produces in the early stages striking triangular patterns, examples of which are shown in Figs. 6 and 7. These etch patterns have proved to be of interest not only intrinsically, but also in that they turn out to be an extraordinarily powerful method of revealing subtle surface (and internal) structure. Indeed the etching attack, if delicately controlled, selects, preferentially, surface and structural features which may differ in height from their surrounds by a mere single crystal lattice spacing. Thus by a kind of developing-up process, an

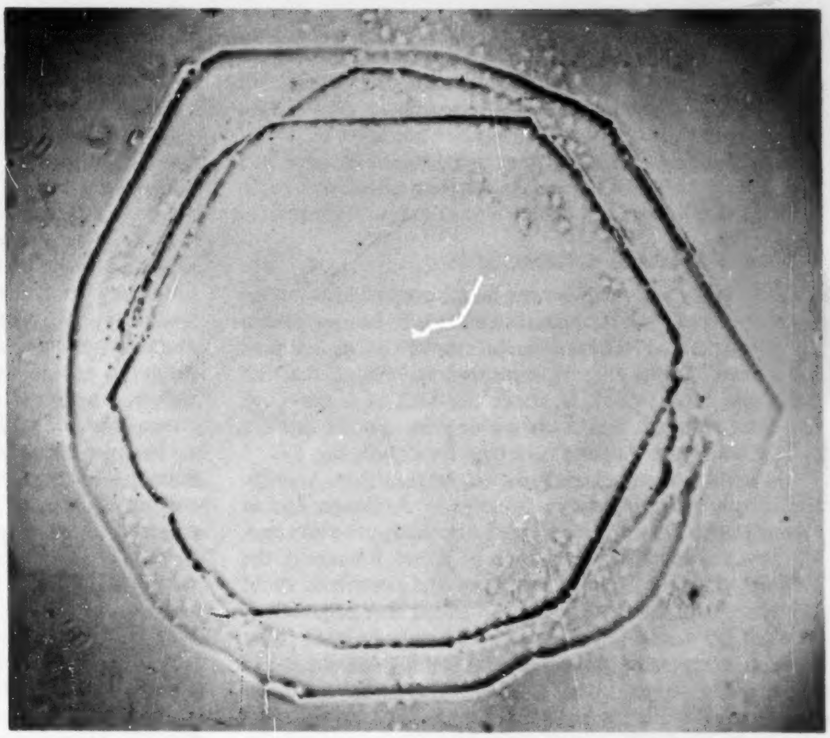
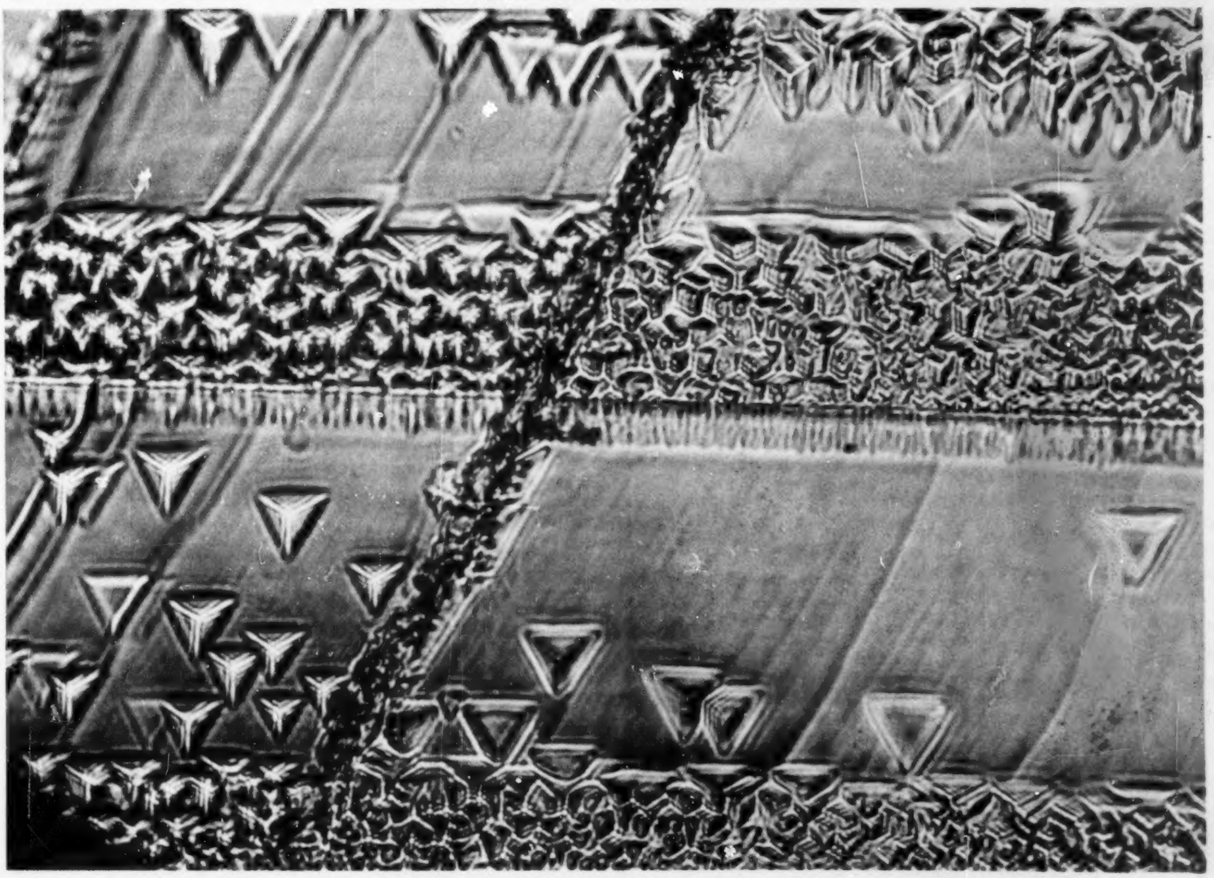


FIG. 5. Multiple ring crack pattern on the octahedron face of a diamond produced from a diamond ball.

FIG. 6. Etch pattern on a cleavage face of a diamond.



unsuspected complexity of structural patterning is revealed. We have progressed a good distance now from Boyle with regard to the behaviour of dissolution agents.

What is perhaps most sobering, when one takes the broad view, is the fact that what were problems to the ancients, still remain as problems to us, although of course we do keep delving deeper and deeper into origins and causes.

SOME FAMOUS DIAMONDS

This brief historical survey will be concluded by an account of some of the famous diamonds in history, all but one of which came from India. Around these, legend has grown. Diamonds are measured by weight, the unit being the carat, which is about one-fifth of a gram. A one-carat diamond makes a sizeable gem. For example, a cube of side ½ cm. weighs a little over 2 carats.

The most famous, though not the largest, stone was the Koh-i-Noor (*the Mountain of Light*). Although Indian legend asserts that this was found five thousand years ago, it is first recorded as a possession of Baber, founder of the Mogul Dynasty in 1526. It was seen and described, about 150 years later, by Tavernier, who stated that originally it weighed 793 carats, but when seen by him had already been reduced, apparently through faulty cutting, to some 280 carats. The lower plane face appears to have been a cleavage. In 1739 this historic stone passed to the Persian conqueror, Nadir Shah, and ultimately, after many vicissitudes, was brought to England and presented in 1850 to Queen Victoria. It was shown at the 1851 Exhibition, and by then weighed only 186 carats. It would seem that the old practice of coin-clipping can be matched by a corresponding practice of gem-chipping! After exhibiting, it was recut to its present weight of 106 carats.

Only second in fame is the Orloff, of 194 carats, a fine brilliant which used to be in the sceptre of the Czars of Russia. Bought in India in 1772 for the Empress Catherine, it too appears to be bounded by a large cleavage plane. In this connexion it is striking to note that a third great diamond (132 carats) was found in India in 1832 being used by a peasant as a fire flint. It has been seriously conjectured that the Koh-i-Noor, the Orloff, and this peasant's stone together formed the original 793-carat stone mentioned by Tavernier. Allowing for polishing loss, the weights are in reasonable agreement.

Next in reputation to the Orloff is the 136-carat Pitt diamond. Bought in Madras in 1702, it found its way ultimately to France to be worn in the hilt of his ceremonial sword by the Emperor Napoleon. Before it was cut, this diamond was reputed to have the formidable size of 410 carats. A stone equally well known is the Florentine (133 carats), which ended up, after a romantic history, in the crown jewels of the Emperor of Austria.

However, in a class by itself is the great Cullinan diamond found in South Africa in 1905. For this was of perfect quality and had the prodigious weight of 3025 carats: over one pound six ounces. Even so, some consider it was a fragment of a still bigger stone. After careful study employing models, this was beautifully cleaved into three large stones to give optimum shapes suited to get the best brilliantcering. These pieces were ultimately cut and polished into four very large brilliants, five medium, and ninety-six small brilliants. The finished weights of the four principal large polished brilliants are, respectively, 516, 309, 92, and 62 carats. It will be seen that this diamond far surpasses anything known in history, either ancient or modern. The Cullinan brilliants now form part of the British crown jewels.

In conclusion it should be noted that diamond is often found in Brazil in an impure form in crude, relatively large masses, not, of course, as individual single crystals like the giants just considered. This form of diamond, called, carbonado, has been found in at least two masses, each even larger than the Cullinan diamond. The largest piece, 3167 carats, was also discovered in 1905.

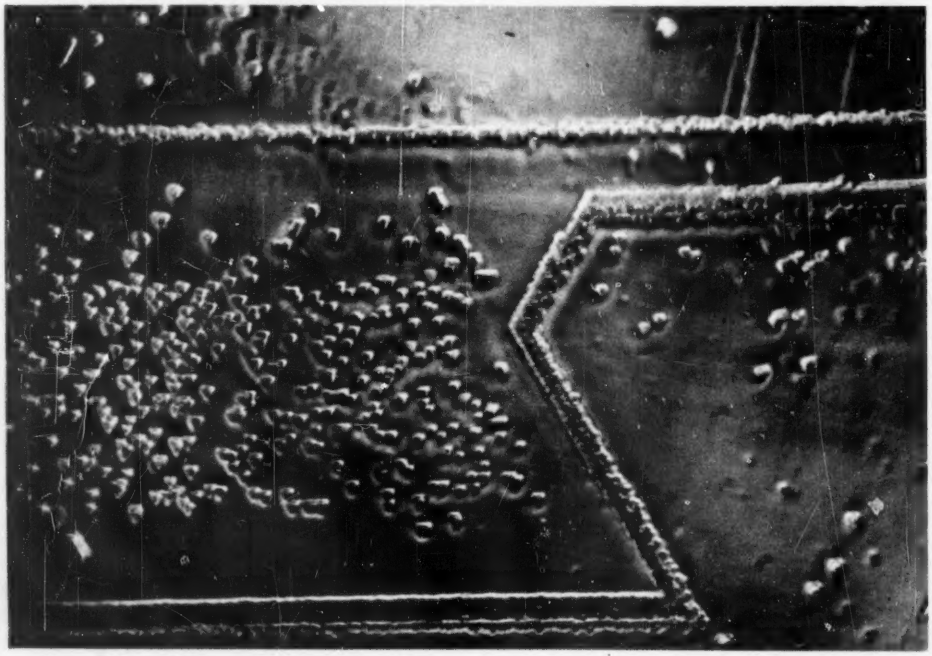


FIG. 7. Etch pattern on a cleavage face of a diamond (×1000).

THE FASCINATION OF NUMBERS

W. J. REICHMANN, A.C.I.S., F.I.A.I.

Numbers are the tools of mathematics, and an understanding of their basic properties is essential to the mastery of any of the many branches of pure or applied mathematics. But they also have a field of study of their own, in which they are considered entirely in their identity as numbers and not as symbols for anything else.

Number Theory is, in short, the science which investigates the many relationships between the numbers themselves or between groups of numbers. To the enthusiast it is a most enthralling subject, but it is often oddly and unjustly neglected by the public at large, even though it offers wide opportunities for research to amateur and professional mathematicians alike. The early philosophers were so intrigued by the fixity and orderly arrangement of these number relationships that they were inspired to ascribe mystical qualities to each of the digits as symbols of divine numerological revelation. This mysticism has been largely eradicated, but the relationships then known and the countless subsequent discoveries together make up a subject which is fascinating indeed.

The study of number behaviour has been ascribed in contradictory terms as useless but beautiful. The claim to beauty of form may be fully substantiated, for the mathematician derives the same aesthetic pleasure from his researches as does the artist from his painting or the musician from his composing and his efforts are as fully creative. What he produces may not as yet be properly appreciated outside his own sphere, but similar limitations apply with equal force to the full appreciation of art or music. On the other hand, it is not true to say that the subject is useless, although many of its more abstruse principles may at first glance appear to have no practical application. No planned study of any field of knowledge can ever be entirely devoid of profit. The restless mind of the research mathematician ceaselessly questing along the seemingly endless alleys of number theory has often found an unsuspected opening to a passage of brilliant light. Such, for example, was the origin of Napier's discovery of logarithms, a system which is based simply and purely upon the general relationship of all numbers to each other expressed through their individual relationships to a single base number.

NUMBER STRUCTURE

One of the most fundamental relationships upon which the structure of numbers may be said to rest arises from the series of consecutive odd numbers. All square numbers, for example, may be built up by the addition of consecutive odd numbers in series, the first term of each series being 1.

$$\begin{aligned} &1 &&= 1^2 \\ &1+3 &&= 4 = 2^2 \\ &1+3+5 &&= 9 = 3^2. \end{aligned}$$

This knowledge at once provides a method for calculating the possible values in the equation $x^2+y^2=z^2$, which expresses the relationship between the sides of a right-angled triangle, and helps to explain why it is possible for one square number to be equivalent to the sum of two other square numbers. For:

$$\begin{aligned} &1+3+5+7 &&= 16 = 4^2 \\ &1+3+5+7+9 &&= 25 = 5^2 \end{aligned}$$

and it will be seen that, as soon as an odd square number (9) appears as the last term in the series of odd numbers, a set of values appears which will satisfy the equation.

$$(1+3+5+7)+9=5^2$$

becomes $$4^2+3^2=5^2.$$

All cube numbers may also be built up from the same series but in quite a different manner.

$$\begin{aligned} &1 &&= 1^3 \\ &3+5 &&= 8 = 2^3 \\ &7+9+11 &&= 27 = 3^3 \\ &13+15+17+19 &&= 64 = 4^3. \end{aligned}$$

Each cube number is the sum of a series but the series for each successive cube follows on from where the series for the preceding cube ends. This is quite different from the process whereby squares are built up. The terms of the series for 3^3 are not included in the series for 4^3, but the series for 4^2 *does* include all the terms of the series for 3^2.

Why should squares and cubes have these properties? Why, for instance, should the number *three* when cubed be equivalent to the sum of 7, 9, and 11? These are the questions which number theory has to answer in a strictly logical way. The answers to these particular questions are in fact based upon a very simple number relationship, although its exposition is too lengthy to reproduce here.

PRIME NUMBERS

One of the greatest number problems which mathematicians have been called upon to tackle is the discovery of some simple general method whereby it would be possible to identify a number either as a prime (that is, without factors) or as a composite. Many ingenious methods have been applied to this problem, but so far no perfect solution has emerged. The renowned French mathematician, Pierre Fermat (to whose fertile brain number theory owes much of its origins and also many of its problems!) devised a system based upon the fact that the factors of (a^2-b^2) are $(a+b)$ and $(a-b)$, so that if a number could be expressed as the difference between two squares, then its factors could readily be ascertained. It is a useful method where the difference between the factors is relatively small; otherwise the procedure is far too lengthy.

Other methods which have been suggested suffer from the same disadvantage or, alternatively, while showing quickly whether a number is composite or not, nevertheless fail to reveal what the factors, if any, are.

NEW TEST FOR PRIMES

In the course of research into the ramifications of the series of consecutive odd numbers, the writer* has been

* W. J. Reichman, "The Fascination of Numbers", Methuen & Co., London, 1957.

fortunate in discovering a hitherto unsuspected basic relationship between that series and all prime numbers. Briefly, it is based upon the fact that all composite numbers may be represented as a series *either* of consecutive odd numbers *or* of consecutive even numbers, but that no prime number may be represented in either way. For all numbers up to 50, the following results were observed:

(*a*) Derived from consecutive odd numbers:
1, 4, 8, 9, 12, 15, 16, 20, 21, 24, 25, 27, 28, 32, 33, 35, 36, 39, 40, 44, 45, 48, 49.

(*b*) Derived from consecutive even numbers:
6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50.

(*c*) Not derived from either series:
2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47.

We have here an entirely new "sieve" in operation, all the primes having been sifted into the third group, and it therefore provides a new test for primality. Theoretically it is a *certain* method of testing *any* number and also reveals the factors, if any, although it does not claim to be any more practicable than the other methods for very large numbers.

If a composite number is built up from an even series, it is itself even and is thus easily recognisable as composite. If a composite number (C) is built up from an *odd* series, it must be of the form of an arithmetical progression with a common difference of 2 between successive terms. Thus, where a is the first term and n represents the number of terms in the progression,

$$C = n(a+n-1),$$

and this is equivalent to (n^2+mn), where m equals $(a-1)$. Since a is odd, then m must be even, so that any odd composite number is either a perfect odd square (where m equals nought) or a perfect odd square *plus* an even multiple of that square's root. What is of even greater significance is the fact that that root (n) is a factor of C and that $(n+m)$ is the other factor. Conversely, if a number *cannot* be expressed in this way, then that number must be prime.

The procedure for this method is as follows where $C = 1111$. The nearest odd square less than C is 1089 ($=33^2$) and:

$$1111 = 33^2 + 22.$$

The remainder, 22, is not an integral multiple of 33, so that 33 cannot be a factor of 1111. A process of elimination eventually leads to the equation:

$$\begin{aligned} 1111 &= 11^2 + 990 \\ &= 11^2 + 90(11), \end{aligned}$$

and the factors are therefore 11 and 101 ($=11+90$).

MECHANICAL AIDS

The checking of individual numbers for primality may now be effected quite rapidly by means of electronic computers but, although they are able to perform this and other processes much more speedily, the processes themselves do not represent any advance in number method. It is interesting to note that, for most of these computers, numbers are first converted from the decimal to the binary scale of notation as it is much simpler for them to differentiate between two symbols than between ten. With only two symbols in use, the symbol *one* may be represented by a positive electrical impulse (which can be registered) while nought may be negatively represented by no impulse at all.

MAGIC OR LOGIC

The enjoyment of tracing number relationships need by no means be confined to the professional mathematicians. Everyone enjoys a good problem, and it is most satisfying, for example, to trace the strict numerical sequences which explain certain apparently magic tricks with numbers. The subject of Magic Squares also opens up wide possibilities in entertainment.

Many basic relationships are in fact revealed by the superficially remarkable properties of certain individual numbers. The number 142,857 is an excellent example, for if this number is multiplied by any number from 1 to 6 the results will always consist of exactly the same set of digits in the same cyclic order but commencing at different points. To multiply it by 3, for instance, all you need do is to remove the digit 1 from its original position and add it on at the end of the number to give the result 428,571. Multiplication by 7, however, produces the number 999,999, and it is this particular result which gives the clue to the reason for this behaviour. If, for the integral number, we substitute the decimal 0·142857 and multiply this by 7, this will produce the decimal number 0·999999, just short of unity. Reversing the process, it becomes clear that the division of unity by the number 7 produces the result 0·142857 with a "carry-forward" of 1 and that the division of this and each subsequent "carry-forward" will repeat the whole process.

Another way of building up this remarkable cyclic number is to take the first two digits and then to double up in successive stages, the results being moved two places to the right at each stage:

```
14
  28
    56
    112
      224
        448
          896
--------------
14285714285 . . . etc.
```

There is yet another way:

$$\begin{array}{lr} 7 \quad = & 7 \\ 7\times 50 = & 350 \\ 7\times 50^2 = & 17500 \\ 7\times 50^3 = & 875000 \\ 7\times 50^4 = & 43750000 \\ 7\times 50^5 = & \underline{2187500000} \\ \text{etc.} \ldots\ldots & 142857. \end{array}$$

The persistency of this number has an apparent quality of magic, but it is in reality based upon the fact that 7 is a prime number and also upon the mathematical principle that the division of unity by any prime number (other than 2 or 5) will always produce a recurring cycle of decimals.

The particular behaviour of numbers composed entirely of the repetition of the digit 9 also gives clues to different relations:

$$9^2=81$$
$$99^2=9801$$
$$999^2=998001$$
$$9999^2=99980001.$$

Any of these squares may be obtained by placing another 9 in front of the preceding square and also adding in a further nought between the digits 8 and 1. Thus, for any number of this particular form, it is clear that:

$$x^2=(x-1)(x+1)+1$$

that is, $$99^2=(98)(100)+1$$

and it is found that this theorem applies equally to all squares of any form. Thus, $7^2=(6)(8)+1$.

FALLACIES

Mathematics is an exact science. In algebra, symbols are used to represent unknown quantities and, if these can be placed into the form of certain equations, then the unknown quantities may be evaluated. The use of these symbols is intended to simplify the calculations, but in the hands of the unwary they may serve only to mystify. If x equals y, then x^2 will equal y^2 and will also equal xy.

From these facts the following equation may be set up:

$$x^2-y^2=x^2-xy,$$

and this can be factorised to:

$$(x-y)(x+y)=(x-y)x.$$

Dividing both sides by $(x-y)$ produces the result that $(x+y)$ equals x, whence $2x$ equals x, and 2 equals 1.

This fallacy lies, not in the algebraic working, but deeper in the basis of number theory. At one stage, both sides of the equation were divided by $(x-y)$, so that, in effect, since x equals y, an attempt was made to perform the impossible feat of dividing by nought to obtain a finite result.

The digital root of a number is obtained by adding its digits together and treating the resulting number in the same way until the final root consists of only one digit. This process provides interesting theorems on the divisibility of numbers and is closely allied to the conception of congruences in pure arithmetic. It should not be confused with the fallacious methods of the numerologists who accord the same treatment to a subject's birth-date and claim from the root obtained to be able to divine the nature and character of the individual and his future fortunes!

PLUTO STARTS UP

Pluto, the latest Materials Testing Reactor at the Atomic Energy Research Establishment, Harwell, went critical at 7.50 p.m. on Friday, October 25, 1957.

Pluto was designed and built to provide the intense neutron fluxes which are now required to help advance the Authority's reactor research programme. In Pluto the behaviour of materials and components for advanced power reactor systems will be examined under conditions similar to those which would be experienced in actual operation. This is done in experimental assemblies, or "loops", built into tubes or "holes" which pass within the intense radiation zone near the core of the testing reactor. At full power Pluto will generate a peak neutron flux of 10^{14} neutrons/cm.^{2}/sec. at a heat output of 10 megawatts. The reactor uses highly enriched uranium as a fuel, and heavy water as both coolant and moderator.

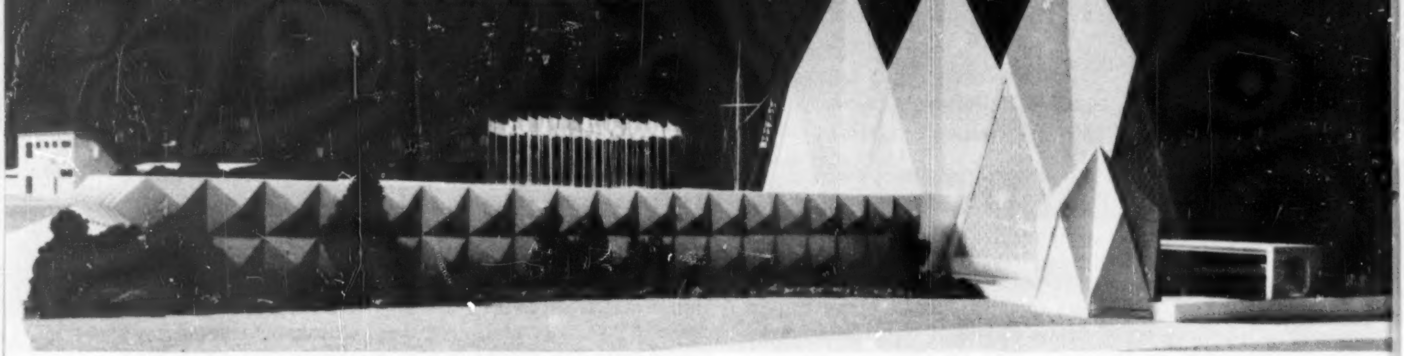
It is similar in design to the Dido Materials Testing Reactor, which started at Harwell in November 1956, but there are fewer "holes" into the Pluto core since these are primarily designed for large testing "loops". A second "Pluto-type" reactor (the DMTR—Dounreay Materials Testing Reactor) is under construction at the Dounreay Establishment of the Industrial Group of the Authority.

The core of the reactor is an array of twenty-six vertical boxes each made up into a composite fuel element from ten curved uranium-aluminium alloy plates: the array of boxes forms a rough cylinder about the size of a tea chest. The reactor is controlled by moving seven cadmium-sheathed "signal arms" into the core between the fuel elements. The circulating heavy water, which is forced upwards through the fuel element assembly for cooling, is contained in an aluminium tank surrounding the core. This core tank is in turn surrounded by a graphite reflector sealed into a helium-filled steel tank and by the concrete biological shield. The heavy water is pumped through the core tank from a circuit outside the reactor: the heat generated by the system is transferred to a secondary coolant, ordinary water, in a heat exchanger in the heavy water circuit. The secondary coolant dissipates the generated heat to the atmosphere in cooling towers outside the reactor building. The whole of the reactor area is enclosed in an airtight shell with controlled entrances so that any accidental release of radioactivity can be readily confined. Eighteen tubes are mounted inside the reactor itself to serve as experimental holes: for example four of them pass horizontally through the reactor close to the reactor core. These holes will be used to hold large-scale engineering loop systems in which fuel, canning materials, coolants, moderators, and constructional materials will be tested under specific design conditions. Pluto will also be used to produce Cobalt 60 at high activity levels for hospital and industrial use.

The Reactor and its associated plant and buildings was designed and constructed by an Atomic Energy Research Establishment team in association with the Ministry of Works and Messrs Head Wrightson Processes Ltd.

BRITISH SCIENCE AND TECHNOLOGY FOR THE BRUSSELS EXHIBITION, 1958

J. GARDNER and CAROLINE HELLER
(Mr. J. Gardner is the Designer of the British Government Pavilion)



The Brussels Universal and International Exhibition opens in April this year. It will be comparable in scale and scope to the New York World's Fair and the Paris Exhibition in 1937, with Britain among the fifty nations to be represented.

International exhibitions have special hazards, perhaps the greatest being that everything shown is assumed in some curious way to "represent" the country showing it. People who visited the Paris Exhibition in 1937 may remember the rather unfortunate effect of the British pavilion. This was a discreet modernistic structure housing hand-made guns, wooden salad-bowls, tennis-rackets, saddles, and high-class boots of the kind one sees standing in tanks of water in Piccadilly shop-windows. The fact that this display correctly conformed to the arts and crafts theme of the Exhibition (totally ignored by most other countries) probably made no difference at all to the bizarre picture of Britain carried away by foreign visitors.

CHOOSING A THEME

The truth is that international exhibitions today cost so much and have such propaganda value that few countries are willing to participate except on a basis of national prestige. Perhaps in recognition of this fact the theme for the Brussels Exhibition has been prudently worded: "the contributions of the nations to the well-being and co-operation of the peoples of the world" allows every country to present itself to whatever it considers its best advantage.

As far as the British Government pavilion is concerned, this theme has at least ensured solid representation for science and technology; but it has made even more acute the problem of what to put in and what to leave out. Britain is not a country like Holland or Finland which has some obviously suitable thematic peg such as "water" or "wood" on which all the displays can be hung. An attempt to sum up this country in any one respect or activity would anyway be misleading. There has therefore been no alternative to the untidy piecemeal progress of discussion and compromise which has eventually determined the general subjects to be covered.

Science and technology will be holding the central position in the British Government pavilion, flanked by sections covering Tradition, Commonwealth and Government, and Arts and Leisure. Science and technology from Britain will also be shown in the International Hall of Science, and in the British Industries pavilion, where certain aspects of industrial research (particularly nuclear power) will be covered.

When the selection of science subjects for the British Government pavilion was started just over eighteen months ago, four main considerations governed the choice. The work had to be intrinsically important and worth showing in its own right. This is obviously the most difficult and critical criterion. Then it had to be "British". This is sensible enough for an international exhibition but often surprisingly difficult to determine in practice. It had to be something which could be displayed properly on a limited government budget, or something for which a sponsor was prepared to cover the cost of display. (An elegant demonstration requiring a litre of liquid helium a day had to go out on this count; also, more seriously, any demonstration of British colour television.) Finally it had to be suitable for display, an essentially practical condition determined both by the mechanics of exhibiting and the audience for which it was intended.

At Brussels this last condition will present special difficulties. The Exhibition will continue daily for six months; everything designed to move up and down, go round and round, or make a noise, must be able to do it for this period. The audience expected at the Exhibition will number about 30 million people from almost every country, occupation, and educational level. All captions will have to be in English, French, and Flemish, and all the displays, while not necessarily interesting to everybody, must be capable of being understood by the intelligent layman who wants to know about them.

It was not easy to find subjects satisfying all these conditions, even interpreting "science and technology" very broadly indeed.

The original idea (admittedly conceived by designers) was to select six or eight recent important discoveries and show them as the cream of British achievement. Difficulties were soon encountered. Among other things, it became clear that even the most co-operative scientists could not be expected to conjure up half a dozen successful projects of world significance to satisfy a designer's dream. This scheme was dropped.

SCIENCE ON DISPLAY

The plan finally adopted and now under way is less tidy, less coherent, and certainly more difficult to design; but it probably gives a more representative picture of the quality and character of scientific and technological work in Britain. Three subjects have been chosen for the main displays: Nuclear Power, Radio-astronomy, and Nucleic Acids. These will be shown in addition to twenty-five smaller exhibits featuring aspects of research, development, or recent achievement in different fields.

Nuclear Power presented a curious problem. On the one hand, so much emphasis will be laid on nuclear power in the Brussels Exhibition as a whole that any approach selected ran the risk of turning out a restatement of exhibition clichés. On the other hand, a liking for understatement would not excuse failure to do justice to British achievement. The result was a compromise (and it is hoped a crafty one) between straightforward self-congratulation and monumental simplicity. Everything has been concentrated in one enormous scene of the Scottish seashore at night, complete with moving waves, clouds going over the moon, and the Dounreay experimental fast breeder reactor. Detailed explanation of past and future programmes, "How Calder Hall Works", alternative reactor systems and research projects has been omitted; they will be seen in the Industrial pavilion. The accompanying text merely describes in a few sentences what Britain has achieved and what is planned for the future. This frankly romantic approach is unlikely to be very fashionable at Brussels. None the less, it may make a refreshing change from the eagerly explanatory technicalities of so much contemporary exhibition display.

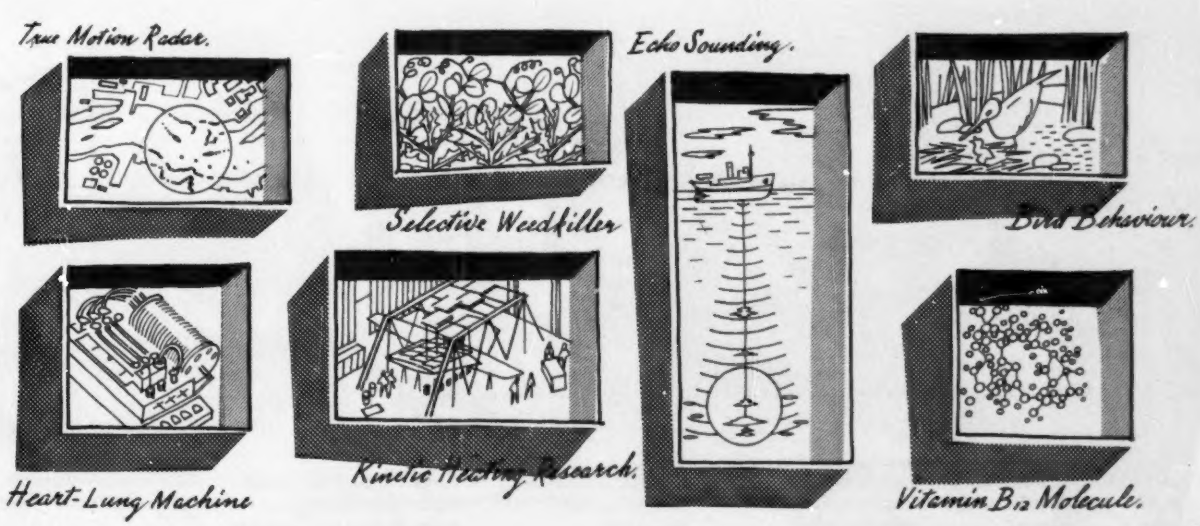
Radio-astronomy and Nucleic Acids will be given a more discursive treatment. The role of radio-astronomers in tracking satellites and the award of the 1957 Nobel Prize for Chemistry to Sir Alexander Todd (among other things for his work on DNA) have confirmed the sense in the choice of these subjects. For the average visitor drifting by, these displays will simply act as a reminder of British activity in these fields; for those people who are prepared to stop and examine the exhibits, they will attempt to give a brief account of the problems that are being studied.

The Radio-astronomy display is flanked by a wall of colour transparency showing the Mullard Interferometer and the Jodrell Bank radio-telescopes. The story is told in a row of exhibits and illuminated panels bristling up abruptly in front of a curved background of night sky. These will describe very briefly the difference between optical and radio information received from space, and will discuss the possible value of radio-astronomy in determining the character of the universe at greater distances and thus earlier periods of time. A final panel will name some of the countries that have made or are making a major contribution to radio-astronomy.

Contrasted with the story of the exploration of space is a display featuring the study of nucleic acids and the chemical basis of heredity. This is dominated by a fifteen-foot model of a section of the molecule of deoxyribonucleic acid. A series of models and specially made animated films explain recent theories of the role of nucleic acids in heredity and their possible method of reproduction.

A REPRESENTATIVE CROSS-SECTION

The remaining twenty-five displays have been chosen as a representative cross-section (or something as close to that as possible) of scientific work in Britain, with an emphasis on research and development. These are shown in brilliantly lit "shop-windows". All the subjects selected, whether they deal with technical problems or long-term research in specialised fields, have been ruthlessly condensed into simple visual terms and a few words of description. The justification for this bold presentation, if any is needed, is that these displays are primarily intended for a



lay audience with no knowledge of science, probably no immediate interest in it, and almost certainly with tired feet. This audience will be shown an exciting series of pictures which will illustrate at first look the subject-matter of British science and technology: molecules, birds, television, fruit-trees, electrical plant, jet engines, cattle, medicine, dyestuffs, aeroplanes, and so on down the row of displays. These pictures are designed to give a vivid impression of ingenuity and variety even to those who do not examine them closely. At the same time, each individual subject is explained in a short text that will be able to give interesting information to the 5% of the audience who may stop and read. This is not an exhibition for the specialist: it is meant above all to convey to the general public the range, interest, and quality of British science.

Any selection of scientific subjects to represent Britain would be open to criticism, and this case is probably no exception. Some subjects have been included for variety and interest, although they might not have qualified on the grounds of intrinsic importance alone. There are certainly some important subjects that have been missed out altogether. Nevertheless, this choice has at least achieved the first aim of assembling together an interesting and impressive range of subjects.

THE SUBJECTS SELECTED

Dr Dorothy Hodgkin's X-ray crystallographic analysis of the molecular structure of Vitamin B_{12} is shown in the first display, with an illuminated model of the molecule and Perspex sections of a three-dimensional Fourier map of B_{12}.

The work of the Fisheries Research Laboratory at Lowestoft is illustrated in an exhibit based on recent experiments using echo sounders to estimate catches of fish and track the movements of shoals at different seasons.

A technique for preserving semen in glycerol at low temperatures, recently discovered by L. E. A. Rowson and Dr Ploge, is shown in a display covering the British contribution to scientific cattle-breeding.

The principles of the Melrose-NEP heart and lung machine, developed at the Hammersmith Post-Graduate School of Medicine, demonstrated by an actual model operating with red ink.

Striking studies of industrial melanism in the Peppered Moth by Dr H. B. D. Kettlewell of the Genetics Laboratory at Oxford are illustrated by films and actual specimens of the moths against their natural backgrounds.

Ultrasonic treatment of milk before deep-freezing, enabling it to be kept in good condition for up to eighteen months, is described in a display of "Frosonic Milk" developed by Dr Dearmouth of the National Institute for Research in Dairying.

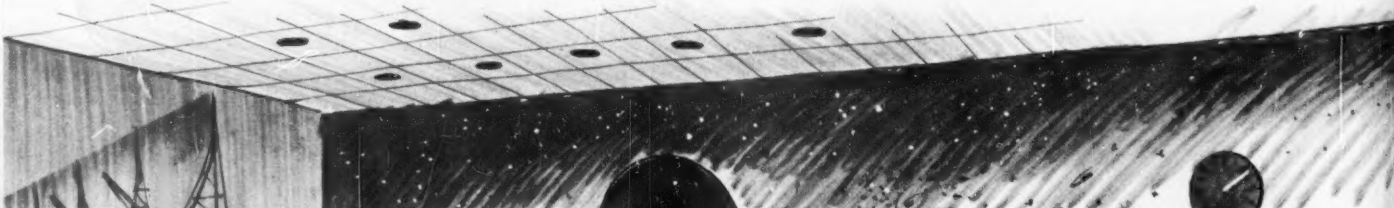
Large models of the site and a reconstructed domestic scene are being made for the exhibit featuring Dr Kathleen Kenyon's excavations of ancient Jericho, the oldest city in the world yet discovered.

The use of giant drainage-ploughs for the afforestation of poor land is shown in a display describing the work of the Forestry Commission in planting new forests.

Recent studies of food-begging responses in Black-headed Gull chicks, carried out by Drs R. and U. Weidmann, are demonstrated with realistic models.

The latest attempt to solve the problem of recording movement in symbols is explained in a description of Benesh Dance Notation.

An animated model loaned by the Royal Aircraft Establishment at Farnborough shows an ingenious structural testing-tank for aircraft, in which the aircraft is subjected to a planned series of stresses and pressure



Transparency showing the Interferometer and Radio-Telescope. Optical and Radio information contrasted. Visible stars and point radio sources. Photographic and recorded radio signals from Cygnus. The relationship of Space and Time.

changes until it falls to pieces so that its life expectancy in service can be calculated.

The work of Prof. T. Wallace of Bristol University on trace elements and their role in plant nutrition is shown in a series of colour transparencies illustrating deficiency diseases in plants.

The latest development of radar by Decca which gives an accurate indication of the actual speed and course of the transmitting ship and other vessels, is displayed in an exhibit including specially made animated film and a realistic model of a stretch of the Thames.

POWER PLANTS AND PEA PLANTS

The underground power-plant being designed and constructed in Britain for the Kariba Hydro-Electric Project on the Zambesi in the Central African Federation is displayed in an animated section model of the site.

More models, in this case scale models of Pye underwater television cameras, are used in a dramatic demonstration of the use of television for underwater salvage work.

Back-projected film taken from the flight deck of an aircraft landing gives a vivid impression of Calvert Airport Lead-In Lighting, designed to give pilots the maximum amount of useful visual information without instrumentation.

The work of the East Malling Research Station on the cataloguing and breeding of reliable root stock for fruit-trees is displayed with pictures of their most successful varieties now exported all over the world.

The Transatlantic Telephone Cable, laid by the GPO and made almost entirely by Submarine Cables Ltd, has an exhibit which uses tape recordings of actual transatlantic telephone conversations to demonstrate the quality of voice reproduction which can now be obtained.

Research into the effects of temperatures at high speeds on aircraft structures is shown in animated film and a model of the Kinetic Heating Testing rig being used at the Royal Aircraft Establishment at Farnborough.

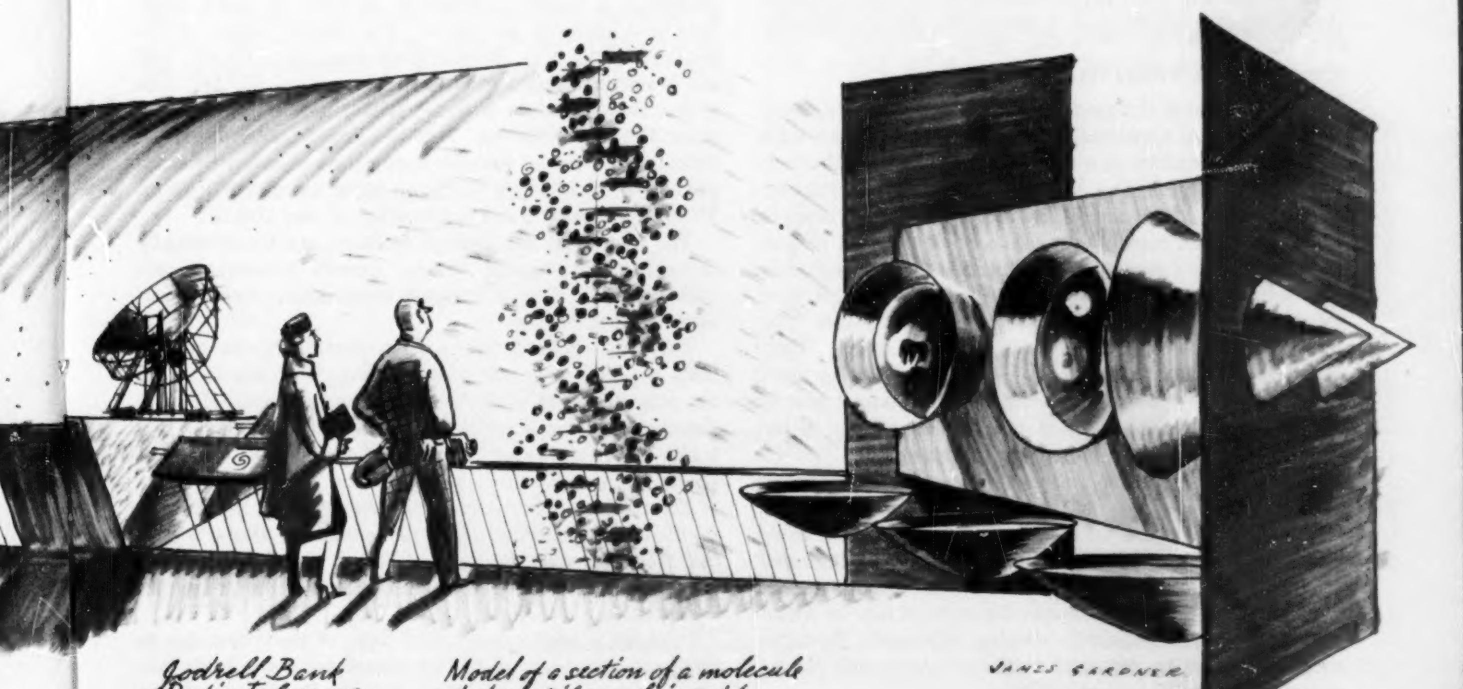
Two more displays show examples of British aircraft development: a modern civil air-liner, the Vickers Vanguard, and a propeller-turbine engine, the Rolls-Royce Dart.

A new loom with greatly improved performance, the product of several years' research into textiles and weaving techniques, has been chosen to illustrate the work of the Shirley Institute, the research centre of the British cotton industry.

Animated model thistles and pea plants are being used to give a lively demonstration of the systemic hormone weed-killers developed by Prof. Wain of Wye College.

Finally, ICI Procion Dyestuffs, the reactive dyes that are one of the most notable developments in synthetic dyes since their discovery just over a hundred years ago, are exhibited in an animated pattern of colour.

Today, space travel, death-rays, and thermo-nuclear power are accepted commonplaces of children's comics. It may be difficult to impress an audience fed on science fiction with the painstaking achievements of science fact; but the success of science fiction in itself shows that there is a popular appetite for knowledge about science and its potentialities. If this appetite has to be satisfied with rich flights of fancy it is possibly because the fact is often served up dry as dust. We believe none the less that recent British scientific work is of popular interest, and that it can be presented in a way that will capture the imagination and curiosity of the layman. It will be interesting to see how far this belief is justified when it is put to the test in a few months' time at the Brussels Exhibition.



A SWISS GUIDED MISSILE

E. STEHLI
Dipl. Eng. ETH

The design and construction of rocket motors and guided missiles is carried out in most countries in government-controlled research laboratories. From time to time, private firms may get development-contracts from these laboratories, but all such work is covered by heavy security measures.

In Switzerland a guided missile has been developed during recent years by private enterprise. The two firms concerned, Contraves A.G. and Werkzeugmaschinenfabrik Oerlikon, Buehrle & Co. in Zürich, are not unknown in England and America, as their anti-aircraft gun, the "Oerlikon", was widely used during the war by the Allied Forces. The article below shows the present stage of progress in the development of the guided missile which is now used for troop training and test flights.

The weapon discussed in this paper is the Contraves-Oerlikon Anti-Aircraft Training Missile. It carries a complete recovery-system which allows the firing of the same missile several times. The tactical version of the Contraves-Oerlikon missile is in principle of the same design as the present training unit, but will carry, of course, instead of a recovery system, a warhead of approximately 40 kg. Furthermore, the tactical unit which is due to be launched this year will carry a larger propulsion charge and thus have a greater range. Besides these two characteristics, the 1958 missile will show many improvements, but no further details about it can be made public at the present moment.

CONSTRUCTION OF MISSILE

The airframe of the guided missile consists of an entirely new light metal construction, namely a thin walled light metal tube wound on to a mould and cemented with Araldite. In developing this novel design the manufacturers tried to retain ideal aerodynamic form of the rocket up to the limit of load capacity for the smallest possible weight. Using the present method of construction they succeeded in producing an airframe which for a minimum weight gave the maximum rigidity and ideal aerodynamic shape. The four delta wings are of the known sandwich design. They are secured to a cylindrical hollow shell, and during flight can be displaced as one unit along the longitudinal axis of the rocket. This displacement enables the stability of the rocket to be adapted to guidance requirements.

The rocket has been designed with strict attention to aerodynamic principles and has four cruciform delta wings to provide the necessary lift for the curved flight. Four smaller tail surfaces also of cruciform design, are mounted at the rear, their main function being to steer the rocket after burn-out (burn-out denotes the point of time at which the rocket fuel is exhausted). During its powered flight the rocket is steered by means of combined gas jet and rudder control which will be described later.

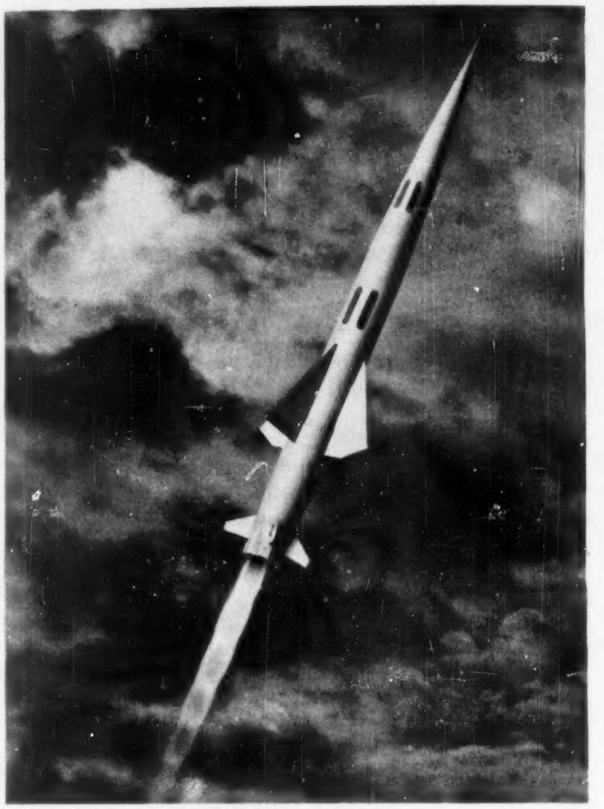


FIG. 1. Rocket in flight.

ROCKET MOTOR

The propulsion unit of the Contraves-Oerlikon rocket comprises a simple combustion chamber in which nitric acid and kerosene are burnt. The overall length of the rocket is about 6 m., its maximum diameter is 40 cm., and the launching weight of the missile is some 380 kg. The rocket is powered by a liquid rocket motor developing a static thrust of 1000 kg. The two liquids, nitric acid and kerosene, are forced into the combustion chamber by compressed nitrogen where they burn under a pressure of about 25 atmospheres and at a temperature of over 2000°C.

The tanks for the two propellants are concentrically arranged with respect to the central pressurised gas cylinder. This gives a compact construction with a minimum of wasted space.

When the rocket motor is to be started, the two propellants are ignited by a chemical igniter. The first thrust of the propulsion unit is developed about 0·8 second after the electrical ignition impulse. The fuel contained in the two tanks is sufficient for 30 seconds combustion, giving a specific consumption of 5 kg./t. sec.

The propellant burn-out height, for example, the altitude reached by the missile after 30 seconds, is about 9 km., but the troop training and test rocket discussed here can be guided up to a height of more than 15 km. after the fuel is exhausted.

In order to stop uncontrolled flight of the rocket due to guidance defects, a propellant cut-off system is built into the rocket to act as a safety device. By means of this

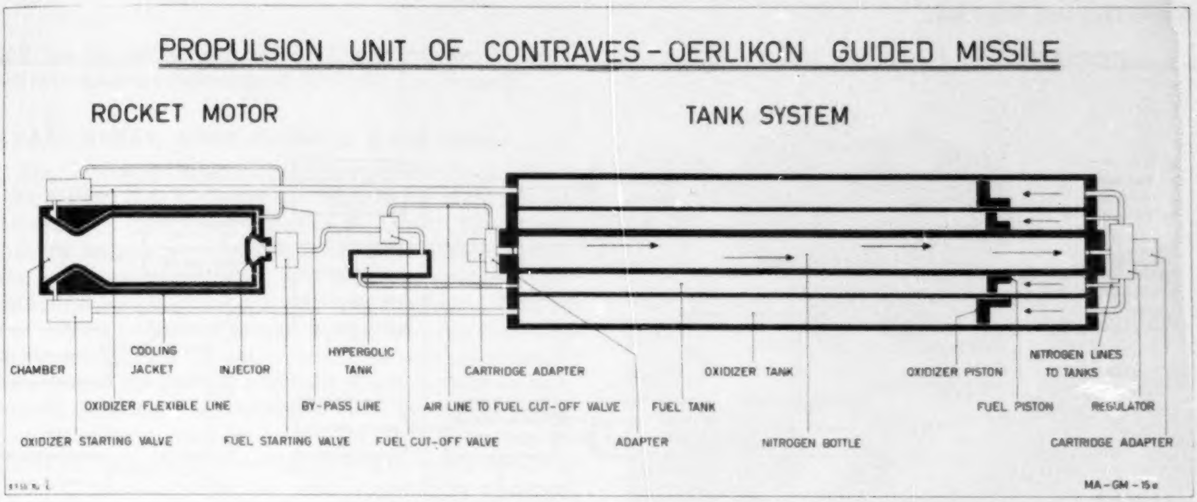


FIG. 2. Diagrammatic representation of the liquid propulsion unit.

device the rocket motor can be cut out at any time during the flight, with emergency division of the rocket and release of the parachutes. This system can be brought into operation from one or more observation posts and operates automatically as soon as the rocket leaves the beam. During troop training and practice flights, guidance and flight performance of the rocket can be checked by means of a new frequency modulation repeating system of high accuracy. The repeated signals and the measured data are automatically recorded by a receiver on the ground.

STEERING OF MISSILE AND RECOVERY

The rocket is steered by deflecting the combustion chamber, hence the gas jet from the axis of the missile. The four tail surfaces at the rear of the rocket are also deflected simultaneously with the combustion chamber and help to produce the turning moment about the centre of gravity required for steering. After the propellant burn-out the rocket is controlled by the tail rudders alone. In order to compensate for the effect of the cessation of the gas jet, the control movements are correspondingly strengthened at the moment of the propellant burn-out.

Rotation of the rocket about its longitudinal axis is not prevented by aerodynamic measures. Rather, guidance is adapted automatically to the rolling movement so that the rocket continues to hold the required direction of flight and flies towards the target with complete accuracy. It goes without saying that such an anti-aircraft rocket, which is a most expensive type of missile, must always be recovered whenever possible during test and training flights. The Contraves-Oerlikon anti-aircraft rocket is designed for recovery after practice flights and for this purpose it comprises two main sections, each section being fitted with a parachute. At a given moment after the propellant is exhausted the rocket breaks up into a head, carrying the electronic control gear, and a tail carrying the propulsion unit. Depending on the propellant cut-off altitude both parts at first fall freely so that the parachutes should not

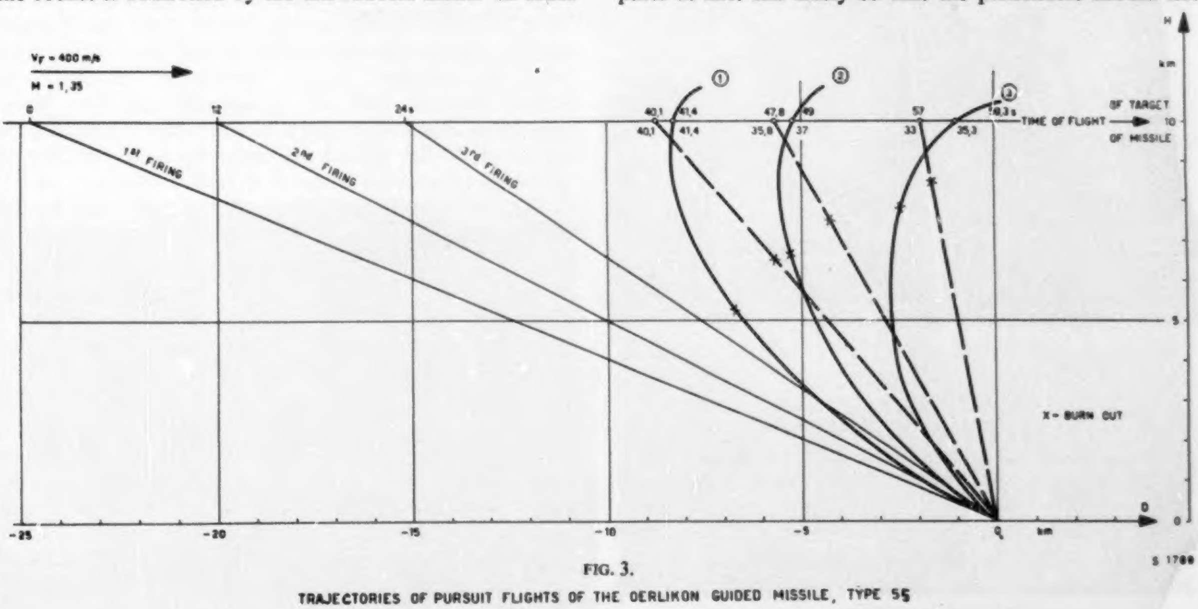


FIG. 3.

TRAJECTORIES OF PURSUIT FLIGHTS OF THE OERLIKON GUIDED MISSILE, TYPE 55

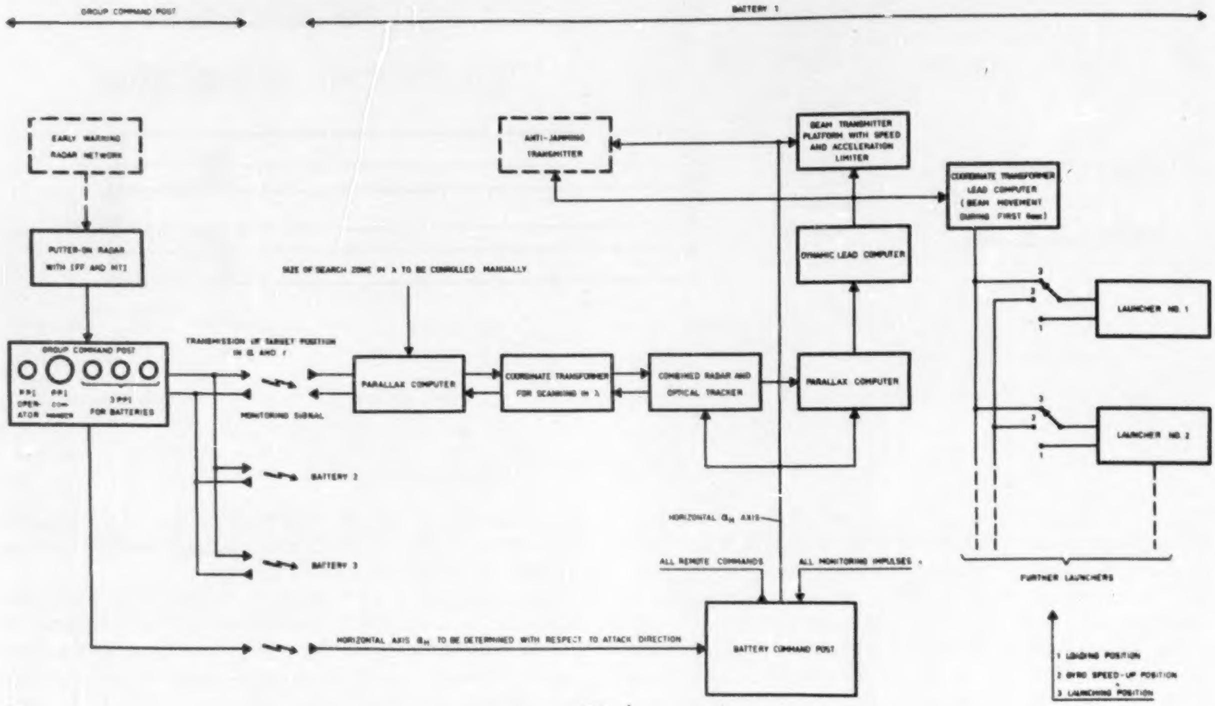


FIG. 4.

GROUND ORGANISATION OF A GUIDED MISSILE GROUP

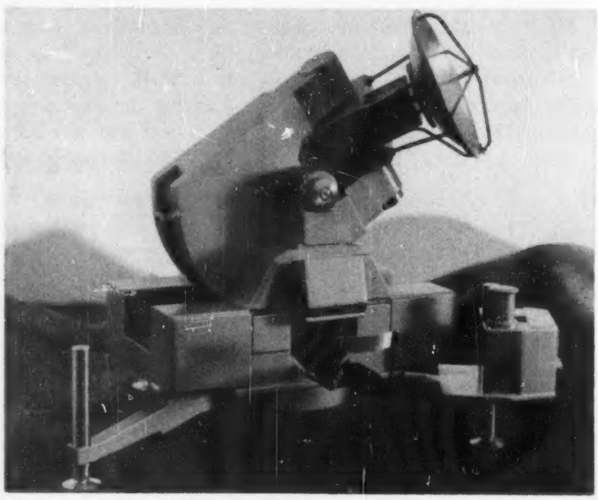


FIG. 5. Radar direction-finder.

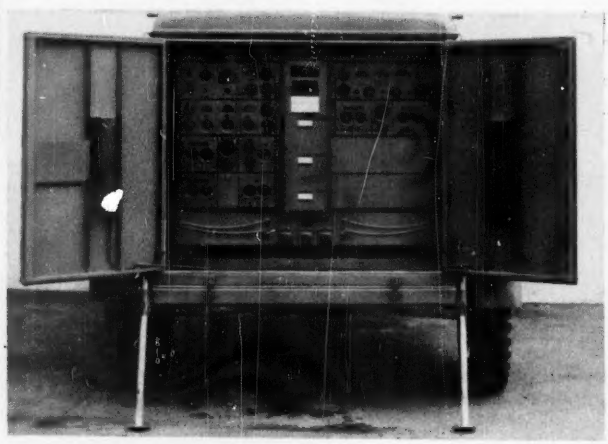


FIG. 6. Computer.

drift too far during high winds. The parachutes for both sections open automatically at relatively low altitudes.

BEAM RIDER AND MISSILE CONTROL

The Contraves-Oerlikon rocket is controlled by the beam rider system, that is, during the whole of the flight it seeks the centre of the beam directed on the target. Thus it will find the target even when the latter takes evasive action. The advantage of the beam rider system of guidance over the command system for example, is its simplicity. Without any special additional ground equipment several rockets can be guided to the target or target area in the same beam. Thus one of the greatest problems of anti-aircraft defence, namely prediction, is eliminated, since the rocket always flies in the beam which guides it to the target. The diagram shows the flight paths of several rockets launched at regular intervals and guided to the same target from a battery position by means of one beam. In constructing the diagram it has been assumed that the target is flying horizontally at a constant speed.

The double launching platform used for firing the rockets into the pilot beam is shown in an illustration. As can be seen from the specifications of the rocket, the launching acceleration is about 2g, thus enabling the rocket to be fired directly into the pilot beam without a long launching path. The rocket is loaded on to the launching site almost exclusively by hydraulic and pneumatic means. After being loaded, the rockets are brought into the required firing angle and firing direction by electrically controlled servo-mechanisms. The control system of the Contraves-Oerlikon anti-aircraft rocket comprises the following principal components: Receiver aerials for reception of the ultra short-wave signals transmitted by the beam transmitter. A separating filter for separating the coarse and the fine signals. A receiver for filtering and demodulating the ultra shortwave signals. Coarse and fine receivers for amplification, control, and demodulation of the sub-carrier signals. Circuit amplifiers for the automatic change-over from coarse to fine beam control and for the conversion of parabolic co-ordinates into cylindrical co-ordinates, and of polar into Cartesian co-ordinates. Control amplifier and gyroscopic unit for introducing the time variable control coefficients for conversion of space co-ordinates into rocket co-ordinates, thus compensating for the roll of the rocket and for the introduction of damping movements about the axis of the rocket. An electrical-hydraulic servo-system to control the rocket by displacing the combustion chamber and moving the control surfaces. And finally an electricity supply for producing the energy required for control by means of a synchronous generator driven by a pressure gas turbine.

GROUND CONTROL ORGANISATION

The ground organisation of a rocket detachment is shown in Fig. 4. An anti-aircraft rocket battalion consists of a battalion command post and three rocket batteries. The control station is equipped with a radar target finder and each of the three rocket batteries possesses its own tracking radar unit. This tracking radar unit is also fitted with an optical direction finder (industrial television chain), so that the crew can effect the angular control of the aiming

FIG. 7. Pilot beam transmitter.

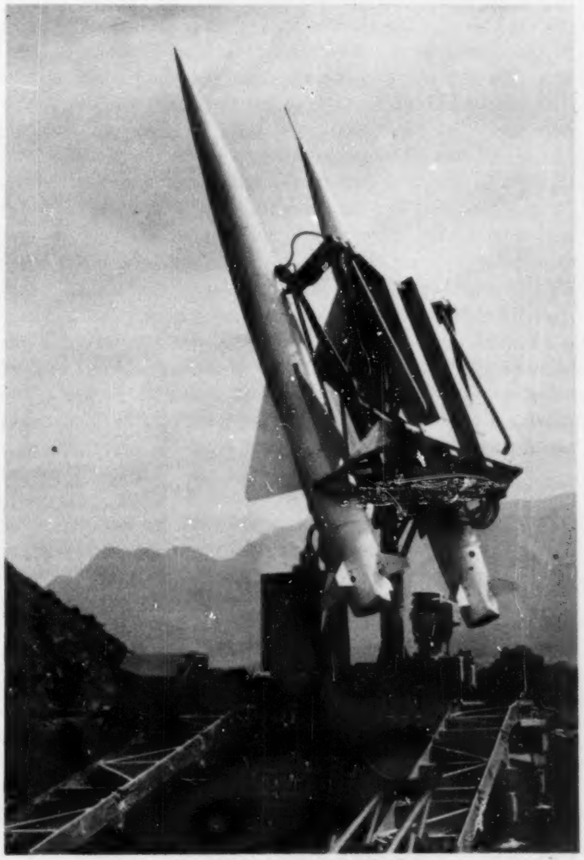


FIG. 8. Double launching-platform.

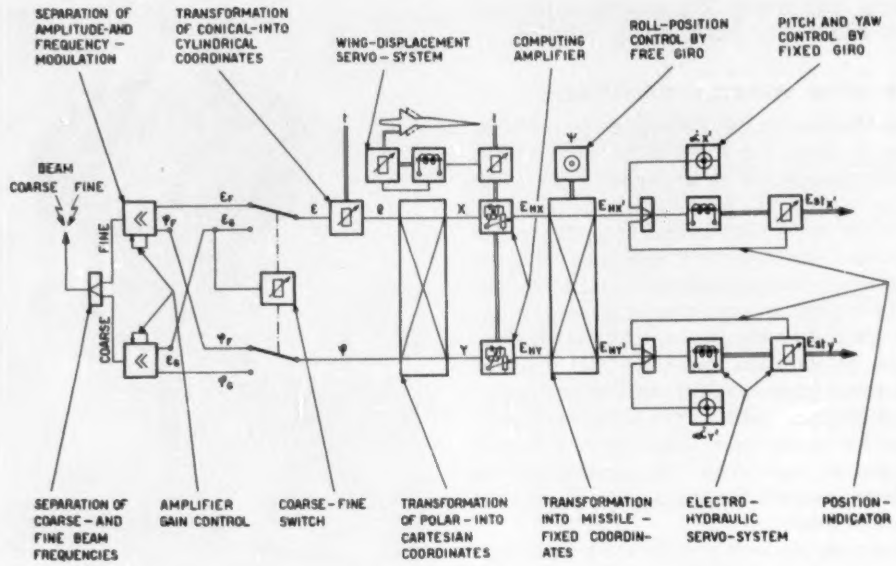


FIG. 9. Block diagram of the controls.

mechanism either by radar or by the optical instrument, depending on the conditions of visibility.

The area of approach of the enemy aircraft is under observation by an early warning radar system for a depth of 300 km. and the alert is passed on to the control station of the detachment. If no early warning network is available, the sky must be watched by the means available to the detachment, namely the target-finding equipment which, depending on the type used, has an effective radius of 150 to 200 km. The targets picked up by the target-finding equipment are assigned to the individual batteries by the control station. The target is followed by the battery with the aid of the radar sighting equipment, and the beam transmitter; the double launching site is thus automatically remote controlled. The transmission of the sighting data from the detachment to the radar aiming equipment and back is effected via a parallax computer, the parallax distance between the target-sighting radar of the detachment and the radar aiming equipment being as much as 30 km. This means, in other words, that the three rocket batteries can be set up at distances of up to 30 km. from the control station.

COMPUTER AND RADAR UNITS

The computing equipment in which all the computers are built into one compact unit, belongs to the rocket battery. The computer equipment comprises the following components: A parallax computer between the target-finding radar of the detachment and the radar sighting unit (parallax max. 30 km.). A parallax computer between the radar sighting equipment and the beam transmitter (parallax max. 200 m.). A computer for the acceleration limitation of the beam movement. A computer between the beam transmitter and the double launching site, one for the conversion of the co-ordinates, one for determining the launching site aiming allowance, and finally a missile angle computer and a wind correction computer.

The beam transmitter is, like all other ground equipment of the rocket detachment, mounted on a mobile carriage. The precision requirements for the control of the rocket are very high. In the same way the requirements for the stability of the transmitter and the transmitter aerial are also very strict, if, for example, positional errors of a few metres in the rocket are to be detected at a distance of 15 km. For this purpose a narrow beam is essential with a very steep modulation curve. This so-called fine beam would, however, be useless for capturing the rocket in the first flight phase, so that for this purpose a much wider beam with a much flatter modulation curve must be provided.

The beam transmitter for the Contraves-Oerlikon anti-aircraft rocket therefore emits a coarse and a fine beam with aperture angles of 22° and 2·3° respectively. The two aerials of the beam transmitter are arranged coaxially and are driven from one and the same motor. As already mentioned the so-called coarse beam is used to capture the rocket after launching and guides the missile into the fine beam, which then guides the rocket to the target. The β–a system has been chosen for the control of the two beams, since it has no singularity in the zenith. The transmitter platform itself can also be rotated in the azimuth (a) but only before the rocket is fired. In order to eliminate the danger of the rocket being lost because of too rapid a movement of the beam, the speeds and the accelerations of the beam movement are limited by a computer. If there is a rapid change of the target in the radar aiming equipment, the beam movement is limited so that the rocket flying therein can follow it.

This brief description of a complete anti-aircraft defence system based on a beam-riding guided missile, cannot go into the many scientific and technical details which had to be successfully developed before the first test flights could be undertaken. It is hoped, however, that this short note will have dealt with the main principles, and as such be of interest to the general scientific reader.

ANNÉE GÉOPHYSIQUE INTERNATIONALE 1957 1958 INTERNATIONAL GEOPHYSICAL YEAR

THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

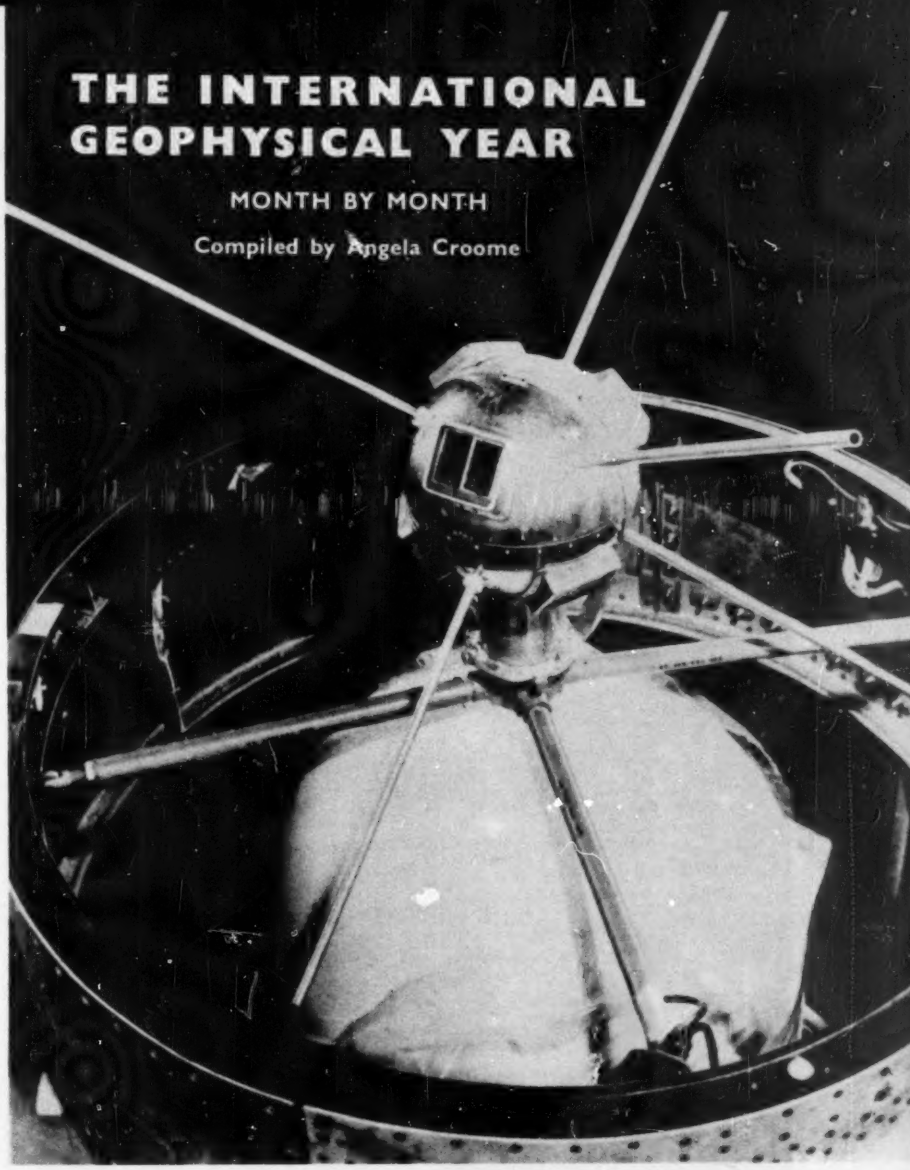


FIG. 1. The 6·4-inch American test satellite weighing 4 pounds and mounted in position on the three-stage rocket, which it was hoped would take it to and place it in its orbit.

British Observations of Sputnik I

The radio observations of the first two Sputniks have revealed very little of what scientists want to know about conditions on the limits of the atmosphere; they were not accurate enough. This became quite clear at the all-day conference on satellite observations held by the Royal Society on November 29.

Mr D. H. Sadler of the Nautical Almanac Office who has been looking after the computation work on the Sputniks, revealed that the radio observations of the satellites received at his office had sometimes been 30% in error. Errors in optical observations (of which there were very much fewer) had ranged up to 5½%. Yet, explained Mr Sadler, for prediction purposes (the beginning of *all* scientific work on satellites) an accuracy of one degree of arc (or an error of only 0·28%) was necessary; for measuring the occasional effects of the Earth's oblateness an accuracy of 0·01° was needed (an error of 0·0028%) and for geodetic calculations an accuracy of 0·001° (or only 0·00028%) error. In order to get accurate visual "fixes" of the satellite reliable predictions of the orbit were essential; and by far the best data for reliable predictions of the orbit were provided by good visual observations. This was the vicious circle which faced satellite observers in this country up to the end of November, since no orbital predictions had been available from elsewhere. But, it was emphasised, *any* observations were valuable when no others existed.

So far, in this country, the volume of radio observations (that is, Doppler shift calculations and "fixes" derived from interferometer measurements) had far exceeded that of observations made by radar and visual means. The weather must be partly blamed for this. No optical observation of Sputnik I had been achieved here at all but an American scientist from the Smithsonian Astrophysical Observatory was able to tell the conference that the first American "sight" had been reported just as he left for London.

In Britain, up till this date, eleven optical observations of high accuracy (that is better than to ½°) had been obtained of the Sputnik I rocket and seventeen of Sputnik II. From the fact that the brightness of the rocket was about 100 times the brilliance of the first Sputnik, Dr R. d'E. Atkinson of The Royal Greenwich Observatory, Herstmonceux, deduced that the object was travelling along nose-first and not tumbling; this made it suitably orientated to give the maximum reflection. It also suggested that its total area was 100 times that of the Sputnik. Mr Martin Ryle, F.R.S., director of the Mullard Radio Astronomy Observatory, Cambridge, had deduced from his observations that the first Sputnik was ejected from its final rocket at a speed 186 cm. per second faster than the speed at which the rocket was travelling. There had therefore been a difference of this amount from the beginning in the relative speed of the two objects in their orbits.

Dr D. G. King-Hele of the Royal Aircraft Establishment, Farnborough, gave an account of what was likely to happen to an orbiting body as its path approached a height of about 100 miles to the Earth (roughly the region at which meteors become incandescent). His remarks were proved substantially correct within the next forty-eight hours which saw the end of the first Sputnik's rocket. He explained that a body in an elliptical orbit progressively loses speed each time it passes apogee; this has the effect of bringing the height of apogee in while the height of

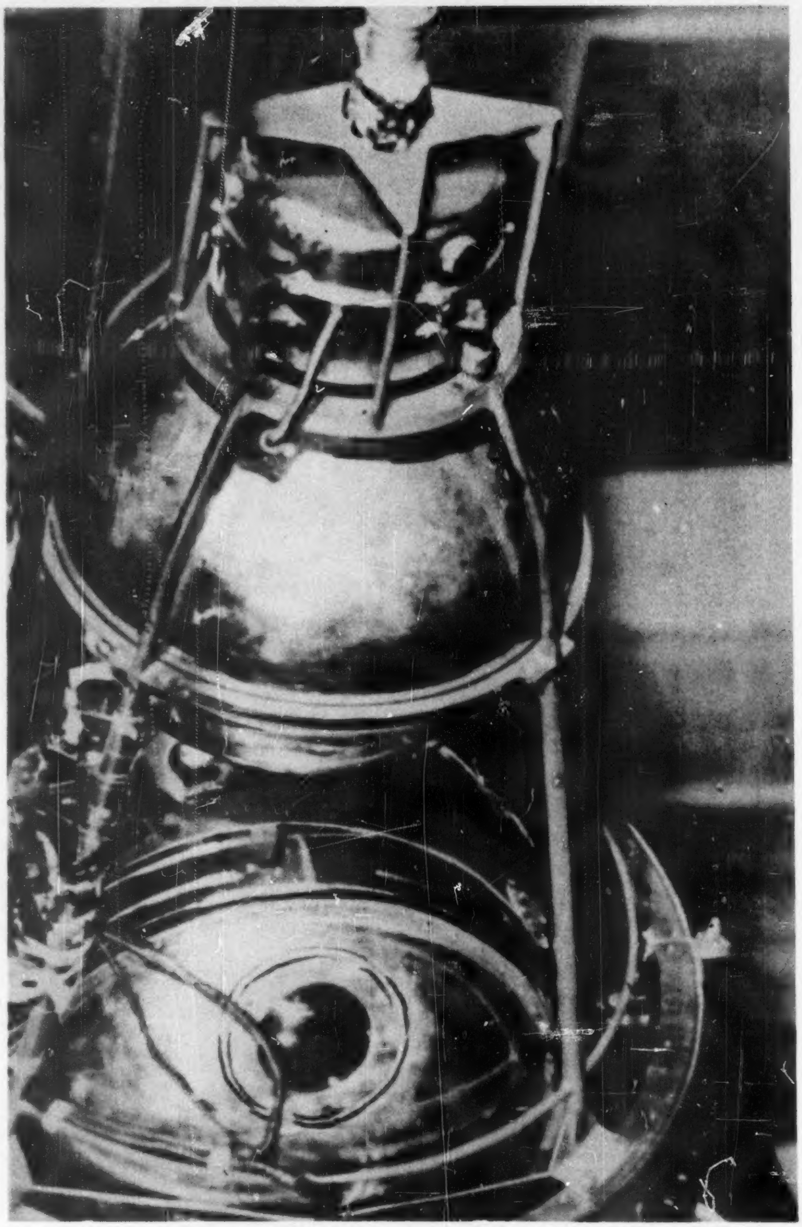


FIG. 2. The component parts of Sputnik II. The spherical container with the port-hole (*right*) is the kennel for the mammalian passenger. The centre sphere carries radio transmitters and other instruments. The end cylinder (*left*) houses the cosmic radiation reader.

perigee remains substantially the same. The overall effect on the period would, however, leave it much the same, for the slowing down at apogee would be offset by an acceleration as the body approached perigee. When, however, apogee and perigee approach the same value, changes would occur very fast indeed; in fact the body might cease to orbit and dive earthwards within one orbit of gaining a nearly circular path. His calculations suggested that when the period had shortened to eighty-nine minutes this critical moment would have been reached.

On November 30, Jodrell Bank announced that its radar observations of the rocket of Sputnik I during the day showed that its period was down to 88½ minutes. The rocket was not picked up again and must be presumed to have vaporised in the atmosphere over some part of the world where observations could not be made or else to have fallen into the sea, some time between 7 p.m. on the evening of November 30 and 5 a.m. on December 1.

Dr J. G. Davies of Jodrell Bank described plans to obtain measurements of electron density at satellite heights using the giant radio telescope. This would be done by making simultaneous measurements of the fading of the Moon's radio "signals" and those of the satellite, both due to the Faraday effect operating in the ionosphere. This would give a value for electron density between the Earth's surface and the Moon for the density between the Earth's surface and the satellite; by taking the difference between these, much valuable information could be gained.

Mr Ryle revealed that, also making use of the Faraday effect, his group had derived a value for density at about 200 km. using their observations of the Sputniks. They got a temperature of 1000°K and a density of 3 to 4 times 10^{-13}. This checked reasonably well with Bates extrapolated value of 700°K and 1·7 times 10^{-13} at this height.

Sputnik II

The second Russian satellite was launched in the early morning of November 3 and was dedicated to the fortieth anniversary of the Soviet Revolution. This actually took place on November 7, but the discrepancy in date was accounted for by the occurrence of particularly favourable weather for launching on the earlier date. In consequence, the launching fell a month, almost to the date, of the firing of the first Sputnik (October 4).

Sputnik II differed markedly from the first Sputnik in several respects. Its payload was nearly six times heavier than Sputnik I (about half a ton), its average height above the Earth after launching was about 694 miles (more than twice Sputnik I's average height), and the orbit was considerably more elliptical; but most distinctive of all was that it carried a live passenger: the dog, Laika.

The scientific objects of the second satellite differed sharply from those of the first. The presence of the dog made clear that **physiological research** into the conditions of life in space was a primary aim. The air-conditioned chamber into which the dog was sealed was instrumented to record and relay the animal's pulse, blood pressure, and respiration; the instruments were also to record various parameters relating to conditions inside the chamber (such as the temperature and pressure). Results showed that Laika had stood up well to the effects of prolonged acceleration followed by several days at zero gravity, and to the sensation of weightlessness.

The fact that the second satellite's path lay, throughout its circuit, above the

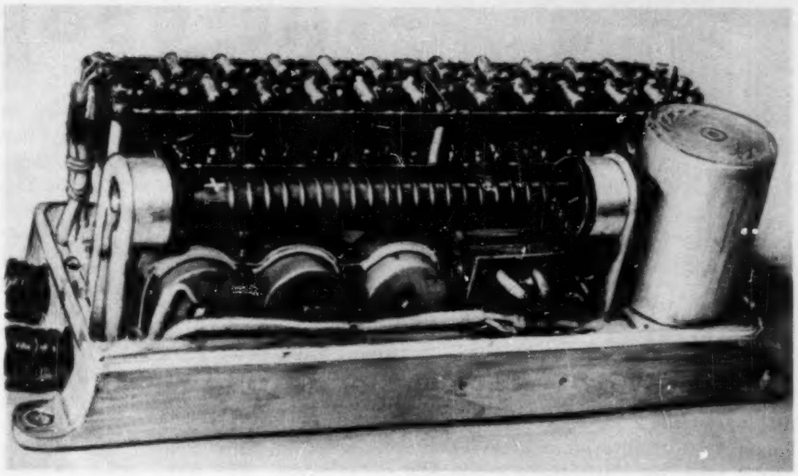


FIG. 3. Instrument for the study of cosmic rays from a Russian satellite.

atmospheric level where cut-off of short-wave and other radiations from outside takes place made it particularly suitable for observing primary cosmic radiation and also solar short-wave radiation.

Cosmic ray measurements were made by two identical automatic counters placed at right angles (see Fig. 3). Because the Earth's magnetic field deflects the cosmic-ray particles by different amounts related to their energies, measurements at different latitudes give an "energy spectrum" of these particles. (Broadly, only particles of the highest energy, and few of these, penetrate earthwards at the Equator; low-energy cosmic rays are more numerous towards the geomagnetic poles.) The latitude range of Sputnik II, combined with its great height, enabled it to give a series of readings of this spectrum before the primaries had been affected by collisions with the atoms and molecules of the Earth's atmosphere.

Preliminary results confirmed clearly the dependence of the intensity of cosmic rays on latitude. Further analysis, taking into account ground measurements of other factors, should help to relate periodic changes in this spectrum with processes taking place elsewhere in space.

Short-wave solar radiation: Three photo-multipliers set at an angle of 120° to each other were used to receive the radiation. A system of filters singled out different bands in the x-ray region of the solar spectrum, and the hydrogen line in the extreme ultra-violet.

Mechanical features of Sputnik II: It was officially stated (by Prof. Blagonravov at a Press conference in Moscow) that the rocket-carriers of both Sputniks operated on the same fuel. It was not disclosed what this fuel was.

Sputnik II's characteristics, drawn from the official *Pravda* statement, are as follows: "Sputnik II, as distinct from Sputnik I, is the last stage of a rocket, housing all the scientific and measuring equipment. This method of housing the equipment appreciably simplified the task of ascertaining the Sputnik's bearings by means of optical observation, since as the experiment with Sputnik I showed, the tracking of the carrier rocket proved far simpler than tracking the Sputnik itself; its brilliance was several stellar magnitudes greater, in fact." (It may be added that the smooth, spherical shape of the first was essential for investigations on air drag, an experiment not attempted on Sputnik II.) "The total weight of the package of equipment, the test animal, and the electric batteries in Sputnik II is 508·3 kg." The weight of the rest is several kilograms more.

The payload of the Sputnik was distributed in three localities (see Fig. 4). In the nose of the final stage were placed the instruments for studying solar radiation, fixed to a special frame. The cosmic-ray apparatus was fixed to the body of the rocket, as was the telemetry equipment and batteries for operating the scientific instruments. A spherical container, similar in construction to Sputnik I, contained the radio transmitters (working as before on 40·002 and 20·005 Mc/s), the batteries for operating the radio equipment, and the arrangements for regulating the temperature (presumably inside the dog's chamber).

The hermetically sealed dog's chamber was cylindrical, while the container housing the radio transmitters was spherical. Both containers were made of aluminium alloys with polished surfaces, specially treated so as to impart the required coefficients of emission and absorption of solar radiation. During the passage of the carrier rocket through the denser layers of the atmosphere the leading (Sputnik) rocket was protected from the aerodynamic and heat effects by a special protective nose-cone. When the last stage went into orbit the protective nose-cone was jettisoned. Overall the Sputnik is reported to be about thirty feet long.

Fuchs and Hillary Meet This Month?

This month (January) it is hoped that Dr Fuchs and his Trans-Antarctic party will make contact with Sir Edmund Hillary and the New Zealanders on the Ross Sea side of the Pole, having successfully completed a crossing of Antarctica for the first time. They will of course have some 700 miles to Ross Island still to go before the crossing can be strictly said to be complete, but the main, unknown part of the journey will be over.

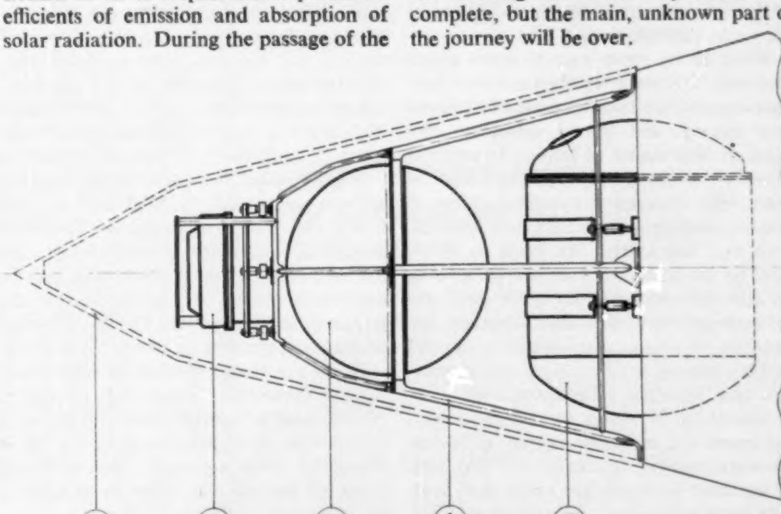


FIG. 4. A diagram of the distribution of equipment inside Sputnik II. (1) A protective cone, discarded after the Sputnik is established in its orbit. (2) Equipment for the investigation of ultra-violet and x-ray radiations of the Sun. (3) Spherical capsule with instruments and radio transmitters. (4) A special frame to which instruments are secured. (5) A hermetically sealed chamber with a test animal.

THE BOOKSHELF

The Darwin Reader

Edited by Marston Bates and P. S. Humphrey (*London, Macmillan, 1957, 486 pp., 30s.*)

No matter whether an original thinker writes little, like Mendel, or much, like Darwin, we are apt to refer to his notions in a version of our own. When Mendel becomes Mendelism or Darwin becomes Darwinism we are bound to be given something second-hand. Indeed, we are normally given a formal stereotyped abridgment. We have abandoned this practice with Shakespeare: we should abandon it also with his opposite numbers in science.

The idea of compiling a Darwin reader is therefore most timely. No one today wants to read, or claims to have read, the whole of Darwin's copious writings. Few English biologists have read more than a tenth part of what he wrote (and that tenth long ago and with little discrimination). No one man could therefore easily produce a satisfactory extract of the whole. Here, however, we have an attempt by two men to extract some 5% of Darwin's writings which will show us his scope and meaning.

What do we most want to know about Darwin? I suppose we want to know how he expressed his main notions of artificial and natural and sexual selection. We want an impression of him as an original observer, as an arranger of arguments, a man who covered the whole range of science dealing with plants and animals, man and the earth. We want to know how he broached the problem of man as an animal, how he invented or gave rise to new sciences like anthropology, or genetics. We want to see where he slipped in his arguments about acquired characters and blending inheritance. We want to see where he stood on still controversial questions, especially human questions like race, instinct, and eugenics. We want to see how he faced his critics and dealt with his predecessors. And we should like to know what impulses of curiosity or vanity or ambition carried him through his vast enterprise which was, after all, the largest coherent inquiry ever carried out by a man.

The answer to all these questions we can learn from Darwin's writings. From this anthology we can learn most of them. And we can learn them with pleasure in a book that is well produced and well printed. The book is likely to be so useful, however, that it is worth pointing out for editors and readers alike where it seems to fall short.

The "Origin of Species" takes up a third of the book, a just proportion. But strange indeed is the use of the expanded sixth edition (of 1872) for abridgment. As I pointed out in a preface to the reprint of the first edition, this was his masterpiece. This alone gives his own individual and undiverted opinions. The later editions are amended and qualified and reorientated to meet criticism. What happened, it seems, was that Darwin began to hedge: he pared away his own theory of natural selection in order to save the doctrine of evolution. And the reorientation became longer and longer and less and less convincing. By taking the sixth edition, written in six stages, the editors have muddled the historical sequence. And they have given themselves and their readers more work with less profit.

Another object of regret is that the editors have left out "Animals and Plants under Domestication". The second part of this book is Darwin's textbook of Heredity and Variation. It includes (or conceals) his most penetrating and most neglected observations on human heredity. And it ends with his greatest blunders: his misunderstanding of the cell theory, and his own absent-minded misappropriation of the theory of Pangenesis which he could have read in Hippocrates. This work is more significant today than what he said about "Vegetable Mould".

We are indeed bound to notice that the editors are zoologists. And they are not concerned with continuing Darwin's analytical and experimental work, his forward-looking work which was largely done with plants. For example, they do not seem to have noticed Darwin's studies of breeding-systems in plants. This work, contained in three other books which they omit ("Orchids", "Forms of Flowers", "Cross- and Self-fertilisation") is the very foundation of population genetics. It is therefore now serving its purpose, although less directly than he imagined, of advancing evolutionary theory.

Finally, this book does a great deal to explain Darwin's achievements. But it attempts to conceal his failures. And it fails to reveal his difficulties. This approach is the common one of historians of science, and is probably due to their unconscious assumption, an unfortunate one, that only success matters in history or in science. One letter (to Asa Gray) helps to introduce reality. But there should have been, inserted in their proper places, a dozen of his most significant letters. Reference might also have been made to the recent book on Darwin, Sir Arthur Keith's "Darwin Re-valued", and also to the "Charles Darwin's Autobiography", published in New York in 1950, a scrappy, anonymous work, which, however, fills some of the gaps in the present book.

All in all, we ought to thank the editors for this book. At the same time we may hope for a second edition. And we may ask for an appendix containing some instructive new items.

C. D. DARLINGTON

Focal Encyclopedia

(*Focal Press, 1957, 1053 pp., £5 5s.*)

The "Focal Press Encyclopedia" is a completely new departure in photography literature, at any rate as far as its scope and size are concerned. It has taken nearly ten years to produce and runs to a million and a quarter words, with contributions from nearly two hundred authors, most of whom are well known in the fields on which they have written.

Nearly every aspect of modern pictorial and scientific photography is covered, and even obsolete printing processes such as Diazotype and Antique are mentioned. There is a useful synopsis of subject divisions at the beginning of the book which gives a good idea of the type of information supplied and would help one to find a subject not clearly listed in the index. The section on applied photography covers an enormous range, including Aerial Survey, Ballistic Photography, Cathode Ray Tube traces, Hyperasteroscopy, Nuclear Physics, Pyrometry. In all, nearly 100 subjects are mentioned in this section. However, the information is, in many cases, fairly brief and does little more than give the novice an idea of what the subject covers. This is probably inevitable, but references to any standard work (where one exists) might be of considerable value.

For the amateur or professional photographer who is primarily concerned with pictorial or general photography there is a wealth of information which cannot fail to whet the appetite and to encourage the experimental tendencies which seem to be the life-spring of nearly all keen photographers.

There are a number of full-length

articles with excellent photographs covering such subjects as Mountain Photography, Nudes Portraiture, and Archaeology, all of which provide sufficiently detailed information for the photographer who occasionally wants to tackle a job outside his own experience. A particularly fascinating article on Pictorialism has been contributed by the Editor: it runs to thirty pages, including thirty-eight photographs, and traces the changes in pictorial approach from the middle of the 19th century until the present day. The growth of photographic clubs and exhibitions at the present day has emphasised the pictorial aspect of photography. Not all photographers are artists, nor can all be trained to produce original pictorial work. Much work seen today is therefore of poor aesthetic quality, and there is a tendency for club members to conform to a completely artificial set of rules and conventions.

The article should be of value in putting the aims and ideals of pictorial photography in true perspective. As it states, "Pictorialism is photographic art for art's sake; mostly pleasant, sometimes admirable, but hardly ever the end in itself it imagines itself to be." Perhaps the artist should always be true to his medium, and the artistic aim should be to represent what is before the camera in the most pictorial way possible.

The encyclopedia contains, in addition to the longer articles, a lot of interesting, detailed items; but characteristics of photographic chemicals, such as solubility, are not always given in the detail required by the practical worker. The size of the encyclopedia is formidable; it is in fact Britain's biggest-ever machine-bound volume. This is a pity, perhaps, for it would be much easier to read and to use as a handy reference book if it was contained in two volumes. There is no doubt, however, that the book is a great contribution to literature on photography, and will be of immense value to those who need a work covering the whole range of photography.

It is to be hoped that the price will not prevent its appealing to many photographers and repaying the tremendous work which has gone into its compilation.

HANWORTH

Isambard Kingdom Brunel

By L. T. C. Rolt (*London, Longmans, Green & Co., 1957, 330 pp., illustrated, 25s.*)

As no biography of this great engineer has appeared since 1870, any new book is a welcome addition to the literature. This biography is absorbing reading and a fascinating story of a very remarkable man. Brunel's was a complex character and the author shows clearly his many unusual facets. The story of his life is one of immense energy and drive, revolutionary schemes, giant achievements, and of failures as well as glittering successes.

In these days of rapid transport and communications, mechanised civil engineering, and of efficient mechanical engineering, it is amazing that one man without any of these things could, in the comparatively short span of fifty-three years, accomplish so much and leave behind him, even after the lapse of nearly a century, so many monuments of his originality and skill that are still vast in size and wonderful in execution.

If anyone can read through this book without becoming absorbed in Brunel himself, and can also do so without experiencing a lump in his throat at certain moments, he must indeed be a difficult person to interest and also one devoid of feeling.

R. MCV. WESTON

Cloud Study. A Pictorial Guide

By F. E. Ludlam and R. S. Scorer (*London, John Murray, 1957, 80 pp. with 74 plates, 12s. 6d.*)

It is an essential part of the training of a meteorologist that he should learn to recognise the different types of clouds; and collections of photographs, called cloud atlases, have been in existence for this purpose for a very long time. The latest and most complete collection is that contained in the International Cloud Atlas published by the World Meteorological Organisation, but this is primarily a technical publication intended as a reference work for professional meteorologists. The book under review is not a cloud atlas in this sense, but a book of delights, sponsored by the Royal Meteorological Society, for the delectation of those who enjoy the beauty of cloud form as well as the study of the weather. As such, it should have immediate appeal to the artist, the nature-lover, and the scientist.

Mr Ludlam and Dr Scorer are members of the staff of the Department of Meteorology of Imperial College, London, and the photographs have been selected from the Clarke and Cave collections of the Royal Meteorological Society, and from the pages of the Society's magazine *Weather*. The authors have departed from the usual principles of cloud atlases in that they have not attempted to find pictures which best illustrate all the types in the international classification, but instead have looked for photographs which show clearly one or more of the main physical processes at work in the atmosphere. In this they have been very successful. The book opens with a short, well-written account of the main atmospheric processes which result in the formation of clouds, and every picture is accompanied by a brief explanation in straightforward language. The introduction is an excellent example of an account of a complicated subject in simple terms, and anyone who takes the trouble to read this section carefully will be amply rewarded. He will learn a lot of meteorology, and will be able to gaze at the sky with an increased understanding of what goes on high in the atmosphere.

There are some very striking photographs in the book. I particularly liked those of cumulus over a lake in Sweden, of mamma beneath the "anvil" of a thundercloud, of fog at Norwich, and of the wall of clouds around the "eye" of a tropical cyclone. The authors have not confined their attention to natural clouds, but have included some excellent photographs of condensation trails from aircraft, including a noteworthy picture of the Lanchester vortices springing from the tips of the wings of a monoplane.

In short, this is a beautifully produced and well-written book which can be recommended to everyone. I have only one complaint: why was the very fine coloured plate which adorns the dust-jacket not included, as it stands, in the book itself? It is well worthy of a permanent home!

O. G. SUTTON

The Making of a Moon

By Arthur C. Clarke (*London, Frederick Muller Ltd., 1957, 180 pp., 21s.*)

At the present time the publication of any new book on artificial satellites is of special interest, and when the author of such a book is an interplanetary authority of the standing of Arthur Clarke, it is especially noteworthy. Publication had obviously been intended to coincide with the launching of the American "Vanguard" satellite, but the fact that this has fallen behind schedule has in no way detracted from the book; actually the successful Russian Sputniks make the predictions applied to Vanguard even more fascinating to read about, particularly when we are able to compare the actual answers already received with the predictions.

The book is a serious study of the problems facing engineers and scientists in the first steps towards the exploration of space, but it is couched in language which is readable by any novice in scientific matters. There are sections which, of necessity, must be a little more involved, but these need not deter the non-technical. As the author says, he is "not concerned with the finer details of rocket engineering", but in appraising the thought and effort that has gone into this first step and in assessing its future repercussions upon mankind.

He traces the history of satellite proposals from the fiction of Jules Verne and others to the fact of active approval by the American Government, announced in 1955. Thence the reader is introduced, almost without being aware of it, to the physical facts of the atmosphere and space above it, the dynamics of satellites, and the rocket engines necessary to power them. At this point the book becomes more specific and discusses the Vanguard project in relative detail. Although a great deal has recently been published in technical papers, this account is probably the best so far for the non-specialist, including what is a very likely explanation for the delay in its launching—the attempt to "compress four years' work into two"!

The next section of the book should be read by all who ask what use the satellite of limited size will be and how we may deduce information from it. Almost certainly the results obtained will raise as many new questions as they answer, but the author goes on to anticipate some of them and the logical steps to solve them.

From this it is an easy step to speculation about space flight, and here the author paints an exciting or depressing picture, depending upon the reader's viewpoint. He expects a tremendous improvement in communications to be brought about, a greater understanding of the planets, of cosmic space and, curiously, of human life. He foresees new war-like roles for earth satellites, but draws comfort from their probable vulnerability to counter-measures. Included at this point is an amusing little chapter on the law of space, a subject which promises to bring joy to the hearts of international lawyers. Finally, the author cannot resist a brief discussion on manned expeditions into "deep" space.

This is a restrained and reasonable account which forms an effective conclusion to a book which is outstanding for its clarity and simplicity throughout. There are many excellent diagrams to illustrate the text and a comprehensive series of photographs. The book is completely up to date but has none of the faults that often mar an effort to rush too rapidly into print. Altogether this discussion of the Earth satellite and its future can be recommended to all who wish for a better understanding of the subject than is contained in the popular press.

A. D. BAXTER

The Rat as a Small Mammal

By H. G. Q. Rowett (*Murray, 1957, i+94 pp., 8s. 6d.*)

This small book is mainly an account of the anatomy of the albino variety of the common rat, *Rattus norvegicus* Berkenhout. There are many clear drawings and diagrams. The muscular system and skeleton, and embryology, are included. Unfortunately, an attempt has also been made to give a general account of the biology of the rat, and this has involved exceeding by far the tolerable limit of errors, for a book designed for the use of students of elementary biology. Among the mistakes is the assignation of laboratory rats to the wrong species; the statement that ontogeny recapitulates phylogeny (in the form taken by the gill "slits" in development); the statement that the "hunger drive" is a "stimulus"; and the statement that "conditioned reflexes" are due to the establishment of connexions in the cerebellum. There are other howlers. The perfunctory and inadequate bibliography suggests a reason why the author has not achieved what he set out to do.

S. A. BARNETT

Animal Ecology, Aims and Methods

By A. Macfadyen (*London, Sir Isaac Pitman & Sons Ltd., 1957, 264 pp., 40s.*)

Several exhaustive treatises on animal ecology have appeared recently, but this book does not pretend to compete with them, though it is a minor criticism that

its title might suggest that it does. It is an introduction to this large and confusing subject intended for students, naturalists, and others on the edge of ecology, and the method chosen is to deal in some detail with certain rather limited aspects in order to illustrate general principles. In this it largely succeeds, though the result is bound to be rather patchy with much of importance left out, so that it can hardly be used as an elementary textbook. The discussions and examples are almost confined to problems of the ecology of invertebrates.

The book is in three sections, and the first deals with the ecology of the individual animal. This is mainly concerned with such matters as the microclimate, and there is an elementary discussion of the various techniques that can be used in such work. There is then a section on population ecology, with especial reference to soil populations and the collecting and sampling techniques that can be used on them; this is well illustrated by examples taken from the author's own work. The section is concluded with two chapters on productivity and activity in soil and aquatic populations. The last and longest section deals with the properties of animal communities, including quite a thorough review of the theory of population ecology, with especial refer- chapter on the relevance of this to practical problems of the biological control of pests, illustrated by well-chosen examples. Finally, there is a discussion of "biocoenology" and the attempts that have been made to apply the ideas of "communities" that have been found useful in plant ecology to the rather different situation in most animal communities. The results have not been particularly successful, but this is a good review of the many serious difficulties that are involved.

The book is a short one for such a very large subject, and it is written in a compact and readable style with a praiseworthy lack of the dreadful jargon that is often found in ecological writing. It can be recommended especially to advanced students who are thinking of going in for serious ecological work. Some misprints were noticed and a few of the diagrams are not particularly easy to follow, but the book is quite well produced, though rather expensive.

C. B. GOODHART

Erratum: It is regretted that in the October issue, 1957, the name of the reviewer of the (NPL) *Proceedings of the Symposium on "The Direction of Research Establishments"* was given as C. B. Dawes. It should, of course, be C. B. Davies, Manager of the Thornton Research Centre of Shell Research Ltd.

TWENTY-FIVE YEARS AGO

RADIOACTIVITY OF SAMARIUM AND ULTRA-SHORT WAVES

"Notes of the Month" in the January issue for 1933 comments on radioactivity. This "ability of an atom spontaneously to emit from its depths either a swift particle or an even swifter electron was thought for [many years] to be a property confined strictly to the very heaviest elements", it says. "The speculative view that all the elements are radioactive has had to be turned down entirely through lack of evidence. Above a limit represented by lead and bismuth everything heavier was radioactive, everything lighter was inactive. The first blow to this simplicity occurred nearly twenty-five years ago when the common and light elements, potassium and rubidium, were found to be radioactive. The radioactivity occurred, however, to a very small degree indeed, and it was the less important particle, the electron, which was emitted in both cases.

"Now comes news from Prof. G. von Hevesy's laboratory at Freiburg in the Black Forest that another light element, this time a very rare one called samarium, is not only radioactive but that it emits the really important and fundamental particle, the alpha particle. If this observation is confirmed, the discovery becomes an important one, because it suggests that the unstable atomic structures of the very heaviest elements may not be so rare as has hitherto been supposed. Samarium has an atomic number of 62 and a mass of about 150. Chemically it is a 'rare earth'. Its neighbouring element, 61, is so rare that it is still doubtful if it has yet been discovered, although it has been provisionally named 'illinium'. It is just possible that the excessive rarity of elements in this neighbourhood may be connected with instability of structure which shows itself as radioactivity."

Marconi's New Experiments

An item in the same issue reports: "In an address to the Royal Institution, the Marchese Marconi described his new experiments with ultra-short waves in wireless communication. He said that the new system was working successfully between the Vatican City and the Papal Palace at Castel Gandolfo. That was an example of what would be a new and economical means of radio-communication free from electrical disturbances, and eminently suitable for use between places separated by moderate distances.

"The new system was unaffected by fog, and offered a high degree of secrecy, by virtue, principally, of its sharp directive qualities. In regard to the limited range of propagation of these micro-waves, the last word had not been said. It had been shown that they could travel to distances greater than had been expected. In any case, the new system was now available for advantageously replacing optical or light signalling in all its long-distance applications.

"Other application such as broadcasting and television were already under consideration, and the study of the new fields of application for these so far unutilised electric waves would soon bring about the design of greatly improved methods and apparatus.

"Long experience had taught him not always to believe in the limitation indicated by purely theoretical considerations or even by calculations, for these were often based on insufficient knowledge of all the relevant factors, but, in spite of adverse forecasts, to try out new lines of research, however unpromising they might seem at first sight. About eighteen months ago he decided to take up the systematic investigation of the properties and characteristics of very short waves, in view of the advantages which they seemed to offer—the small dimensions of the radiators, receivers, and reflectors necessary for radiation and receiving a considerable amount of electrical energy—and in view also of the fact that they did not suffer interference from natural electrical disturbances as atmospherics.

"The Marchese explained that following experiments with waves of the order of 50 cm. length, conducted between his yacht and a station near Rome, the most outstanding result was the successful establishment of communication over a distance of 168 miles on a wave-length of 57 cm. All previous distance records of communication by means of wave-lengths below one metre had thus been surpassed."

LETTERS TO THE EDITOR

Athanasius Kircher and the Magic Lantern

Sir:

My attention has been drawn to a recent article* by R. A. Houstoun in which he challenges the long-accepted opinion that Athanasius Kircher was the inventor of the magic lantern. The article is of particular interest because the magic lantern later provided the projection principle for cinematography and in itself was a very important instrument for the dissemination of popular science in the last century. It was so highly esteemed by some, in fact, that the famous optician, J. H. Dalmeyer, rechristened it the "optical lantern" as being more appropriate to a scientific instrument. It was far from this when Kircher mentions it in his book *Ars Magna Lucis et Umbrae*, and as Houstoun rightly points out, is so inaccurately represented in the accompanying illustrations to the second edition of this work that one at first wonders whether the optical principles involved were known to Kircher at all. This leads Dr Houstoun to refute any claim for Kircher as the inventor, and he supports his argument with a quotation from the *Allgemeine Deutsche Biographie*, where it is stated that Kircher is thoroughly unreliable and a charlatan; moreover, in the opinion of experts the whole of his published works contain not one addition to knowledge. The quotation then goes on to state that "the instruments which he discovered are mostly trifling; the most interesting would be the magic lantern, if this is really Kircher's work". Houstoun sums up with a short sentence: "His drawings and the accompanying text make it almost certain that it is not." But how certain is this premise? Before we can accept it there are one or two points to be cleared up.

Gaspar Schott, who was a pupil of Kircher's, also wrote on the magic lantern and suggested several improvements in its construction; moreover, he coupled Kircher's name with the instrument (*Magia Universalis Naturae et Artis*, 1677, p. 424 *et seq.*). Other contemporaries of Kircher also attribute the invention to him: George de Sepibus Valesius (*Musaei Collegii Romani*, 1678, p. 39 *et seq.*) and Johann Stephan Kesler (*Physiologia Kircheriana*, 1680, p. 124 *et seq.*). It seems reasonably certain, therefore, that Kircher must have had such an instrument, or demonstrated one, or at least seen one; in which case he would have been perfectly aware of the optical principles involved. The fact that the engravings in his books are not drawn with any exactitude does not necessarily prove that he had no knowledge of the apparatus. The edition with the illustrations which Dr Houstoun criticises was published at Amsterdam, and it is quite possible that they were engraved by someone there who did not fully understand Kircher's rough sketches. Amsterdam was a long way from Rome in those days.

In the first edition of *Ars Magna Lucis et Umbrae*, published at Rome in 1645, there is a description and wood-cut illustration of a very elementary form of lantern, which nevertheless contains the rudiments of a modern projector, and which incidentally has prompted the Jugoslovenska Kinoteka to use the illustration as a device on their letter-head. Dr Houstoun dismisses this *lucerna catoptrica*, as Kircher terms it, as having no relation to a true magic lantern, whereas in fact it is the very thing in embryo. So if we do not know for sure whether Kircher was the actual inventor of the magic lantern, we do know that he was the first to describe it in print, and this alone gives him priority until such time as other information to the contrary comes to light. Certainly Dr Houstoun has not produced it.

JOHN BARNES

Mousehole, Cornwall.

* *Science Progress*, 1957, July, p. 462. (See also *Nature*, 1957, p. 583.)

Nobel Prizes

Sir:

An editorial (DISCOVERY, 1957, vol. 18, No. 3, p. 89) reviewed the requirements set down by Nobel for the awarding of the Prizes, and compared them with the conditions under which they were actually given. You recommended that Nobel Prizes should go to young scientists, and many people in Sweden and elsewhere were in full agreement. Now it seems that even the Academy of Sciences and the Carolingian Institute, who choose the Prize-winners, have taken to heart the remarks and criticisms made in your editorial.

To most of those interested—and who is not interested in the decisions made by the Nobel Prize Committees?—it came as a complete surprise that the distinction went to comparatively young people this year. Dr Chen Ning-yang is only thirty-five, and his friend Dr Tsung Dao-lee is only thirty-one. Newspapers point out that only once before (1915), when a twenty-five-year-old Englishman, W. L. Bragg, got the Prize in Physics, has there been a younger scientist to receive the distinction.

I have recently had the opportunity to point out that your journal really made headway with leading Swedish newspapers in questioning the appropriateness of the Committees' "playing safe" by electing only well-established, older scientists whose future work was more likely to come up to expectation (and, by doing so, not being true to the real intentions of Nobel himself). Also, many Swedish scientists, members of the Prize Committees, really agreed with DISCOVERY but were unwilling to say so officially. Now, however, there is general pleasure over the youth of Drs Chen and Tsung, and the recognition of Bovet and Todd.

Sir Alexander Todd's work has been highly praised in *Dagens Nyheter*, Sweden's leading daily newspaper. In an article by Prof. Einar Hammarsten (the son of Olof Hammarsten, who was one of the first to tackle the problems related to proteins), the importance of Sir Alexander's work is described in detail. It cannot be doubted that, beyond its practical importance, Sir Alexander's work (and indeed the work of all this year's Prize-winners) deserves the award as consistent with the intention behind it. For, as Nobel required, the Prizes should go to those "who have rendered, during the previous year, the utmost good to humanity . . . without regard to nationality".

H. HERZ

Angelholm,
Lergoksgt, Sweden.

The Philosophy of Synthesis

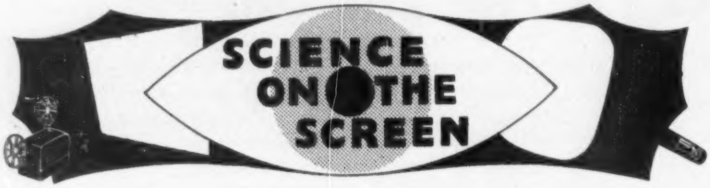
Sir:

It may be that, to men of the intellectual attainment of Huxley, there is no use for a God, but can that be said justly of the vast mass of humanity?

When man has lost belief in anything superior to himself he has lost the germ of self-improvement, and until scientists, who after all must have learned that Nature is greater and more powerful than they, can provide a good and acceptable substitute for the so-called Laws of God, they should be very careful how they discount, or appear to discount, matters which, properly regarded, are rules for the survival of civilisation.

H. TRENCHAM

Ruislip, Middlesex.



Teaching on TV

We might as well resign ourselves to having science television broadcasts relegated almost exclusively to the schools, for these schools broadcasts persist in being the primary scientific oases in an almost barren wilderness of entertainment. The BBC for the time being seems to be making a concentrated effort on "Science and the Weather", transmitting as much as two such school broadcasts in the one week, the one dealing with Winds (November 11), the other with Clouds (November 13). This is of course a safe subject and highly desirable, yet not too imaginative. ITA, on the other hand, has begun a highly enterprising and well-conceived school series of nine weekly programmes, "World of Figures", planned in two sections.

The first five covered calculation, space, and time; it was, so to speak, "pure mathematics". The last four, on the other hand, are concerned with the applications of mathematics to practical purposes. On the whole the first five programmes were really successful in achieving the clear objective of clothing with emotionally toned interest the otherwise dry bones of mathematics. The range covered was certainly ambitious. The first lesson dealt with prehistory and the evolution of mathematical symbols; the second, devoted to the art of computation, began with the abacus and ended up with giant electronic computing machines. Lesson three demonstrated the evolution of geometry, placing particular emphasis on its practical nature in early times. The fourth programme concentrated on geodesy and survey. The last programme of the series, the most ambitious of all, set itself the task of explaining the evolution of modern methods of assessing and measuring Time.

This broadcast on Time contained much of real value. Basically it aimed at explaining the origin and significance of the seasons, and simultaneously dealt with time measurement. It contained an enormous amount of material, too much I am sure. In fact this criticism can be levelled at every one of the broadcasts yet given in this series. The amount absorbable in half an hour by the young is depressingly meagre and this must be borne constantly in mind. There ought to be a recapitulation after the major content of each lesson; there very rarely is. There were some well-thought-out animated diagrams, and particularly convincing was that illustrating the difference between the solar and the siderial day, a difference very hard indeed to explain to young pupils.

On looking back over the series, one can say that on the whole, the five broadcasts have exploited to advantage the specific characteristics of the TV medium. There have been lapses; for instance, the last broadcast dealing with Time had one glaring weakness throughout: during the whole half-hour one saw the teacher only at the beginning and at the end for brief moments. One heard his voice as a background running commentary to some admirable film sequences and well-planned diagrams. One saw a close-up of his hand, or of his pointer moving over a diagram, but one saw no teacher, and the cameras did not offer even a single gesture to support, emphasise, or clarify points at issue. This is a failure to exploit the most important factor in good teaching, namely the teacher's personality.

On the contrary, the first lesson in the second half of the series, which on November 12 dealt with the science of the navigation at sea, was a delightful example of admirable use of real TV possibilities. It consisted of an illustrated conversation between the teacher (John Richmond, who asked exactly the right questions at exactly the right places) and Commander P. R. G. Smith of the Royal Navy. The talk was apparently staged in the charthouse of a ship at sea, and the Commander proceeded to show how he charted his course and navigated his ship from Gibraltar to Portsmouth. It was all very natural and very convincing indeed, and one had the impression that the teacher was an inquiring passenger on a very real ship at sea. The gyro-compass, the fixing of bearings, the use of the sextant, echo sounding, radio fixes, radar navigation scanning aids, all were described. Certainly again too much material, but oh, so very much alive, and such a treat to listen to. A really good broadcast like this makes up for the deficiencies of others. Yet it is evident that a very great deal of preliminary preparation is needed to secure so neat and tidy a presentation, which so closely simulates reality. All concerned, John Frankau who directs, John Richmond who writes and introduces, and Kenneth James who illustrates, are to be congratulated. It is to be hoped that all television producers will set their sights as high. Both ITA and BBC producers should be warned against exclusive use of film; it is a trap both have fallen into in the past. S. TOLANSKY

One Man's Challenge

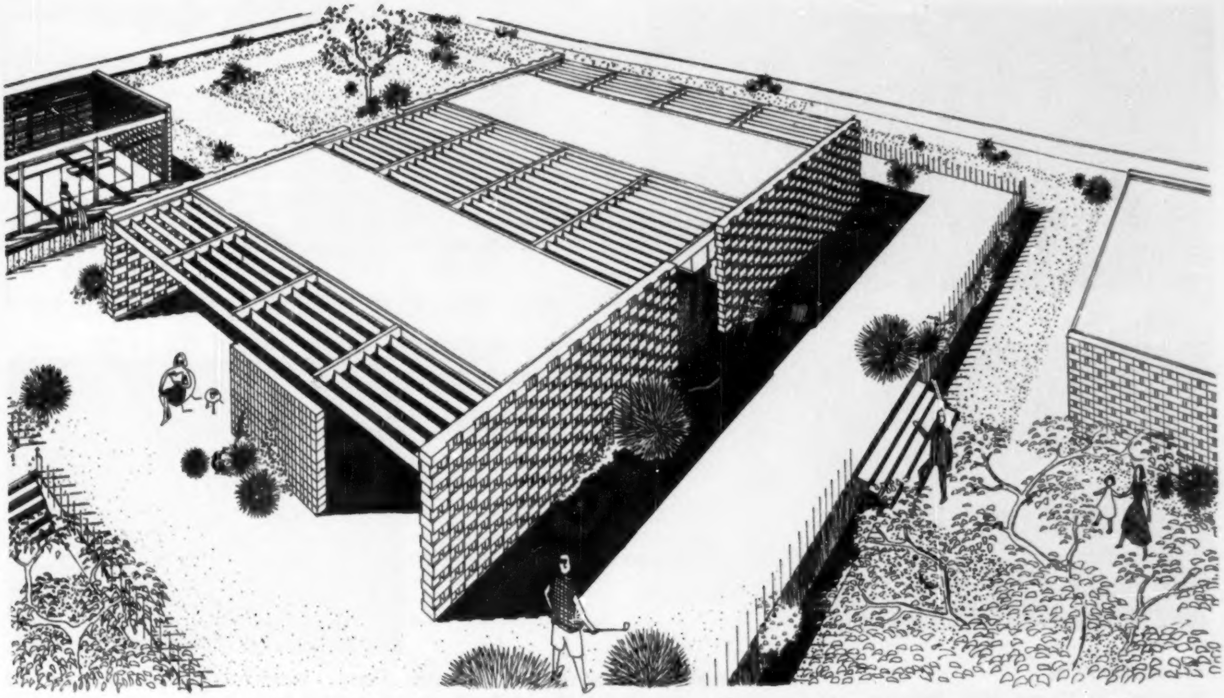
Produced by Derek Stewart with Peter Cardew. Written and directed by George Noordhof. 35 mm., black and white; 20 minutes. Sponsored by Lloyd Hamol Ltd in association with The Empire Rheumatism Council.

This film, which enjoyed recent release, satisfies such varied interests that one is moved to speculate as to how it is most likely to be used. It is a human-interest film about a medical problem, namely, the long-term crippling effects of rheumatism. The object is presumably to present to the chosen audience an idea of how even severe disability can be overcome, and one could imagine that the film is capable of giving hope to patients and inspiration to social workers. Furthermore, the subject is handled with such sensitivity, and at the same time common sense, that the film is also possibly suited to the more serious public-cinema audience.

The film comprises the personal story of a man who, having been afflicted with rheumatoid arthritis for a number of years, finds himself as an end result to be a helpless cripple unable to move his arms or legs or to do anything for himself.

Refusing to accept this situation, however, he uses his mental ingenuity and what little movement is left to him to overcome his disability. The film follows his progress and shows how he tackles and conquers obstacles which at the beginning of the film seemed far off, until finally we see him able to propel himself from one place to another and, besides proving capable of attending to his immediate needs, we find that he is also able to do a job. Throughout, the determination and cheerfulness of this real-life subject emerge as an infectious example.

The Empire Rheumatism Council, for whom this film was made, has clearly gained a feature of great potential worth, but the story does not end here because the production was made possible by the sponsorship of Lloyd Hamol. This is, therefore, at the same time an example of commercial sponsorship in its best possible light. PETER HANSELL



Solar Houses Competition First Prize: Peter R. Lee, Minneapolis, Minn., U.S.A.

FAR AND NEAR

Solar Houses, Competition

The Association for Applied Solar Energy have announced the winners of the International Solar House Architectural Competition which they sponsored. The purpose of the competition was to obtain original designs for a residence especially adapted to "living with the sun" on an irrigated desert site north of Scottsdale, Arizona, U.S.A. The winning designs were selected by a five-man jury which met first in Phoenix on September 13 to inspect the site at Sundown Ranch Estates, five miles north of Scottsdale, where the house will be built. On September 14 they flew to the Grand Canyon, where three days of intensive study were needed to give adequate consideration to the 113 entries submitted by architects and designers from thirteen nations.

The prize-winning house will be built by G. Robert Herberger of Scottsdale and Minneapolis as soon as the detailed plans can be completed. Its solar collectors will supply the heat needed to keep the residence comfortably warm during the winter, to heat the domestic water, and to warm the swimming-pool which is an integral feature of the design. Auxiliary heat will be supplied by an electrically-operated heat pump, which will also provide summer cooling. Storage of heated water in winter and chilled water in summer will be in a large buried tank. The engineering of the installation will be done by the Albuquerque firm of Bridgers and Paxton, who designed and built the world's first solar-heated office building.

The solar house will be put on public exhibition early in the spring of this year. It will then be used as a living laboratory by the Association for Applied Solar Energy and will be the centre of interest at the first Solar House Symposium, which was held in September by the Association in co-operation with the University of Arizona and Arizona State College at Tempe.

New International Standard of Length

The Advisory Committee for the Definition of the Metre has recently passed a resolution that the world standard of length should no longer be "M" (the bar of platinum-iridium kept in Sèvres, France) but a wave-length of light emitted by a krypton isotope of atomic weight 86.

The decision was based on recent research in the U.S.A., Russia, Japan, West Germany, France, England, and Canada. The use of light as a yardstick has been attractive ever since it was first suggested by J. Babinet in 1827, but no known light-source was entirely suitable as a base for the metre until recent years, when isotopes became available.

For the past few years, top contenders were mercury 198 (transmuted from gold —an interesting product of nuclear research), krypton 84, krypton 86, and cadmium 114. All of these had excellent characteristics, and it was a long time before krypton 86 won out by a unanimous decision. The new standard metre is 1,650,763·73 times the chosen wavelength of krypton 86. It is well over 100 times more precise than "M", the seventy-five-year-old bar of metal.

In view of the fact that modern industry is demanding higher and higher degrees of accuracy, the difference of a hundred millionths of an inch more or less is of extreme practical importance.

To an old-time mechanic, meeting a tolerance of a one-thousandth part of an inch was an achievement. Today a ten-thousandth is common practice, and the master gauges controlling interchangeable manufacture are measured in millionths of an inch. The accuracy of these gauges is maintained by checking them against the best available standards. These master gauges, more than any other single factor, made mass production possible.

FIG. 1. Bacteriophage particles. Magnification ×80,000.

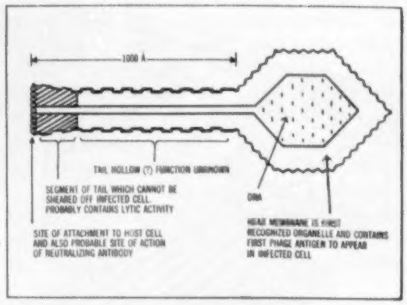


FIG. 2. Schematic diagram of a phage particle.

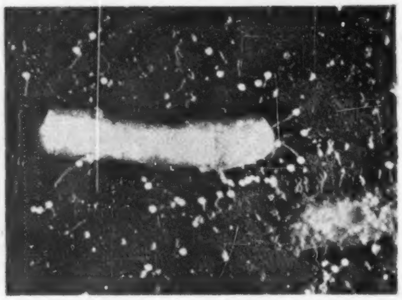


FIG. 3. Adsorption of phage cells.

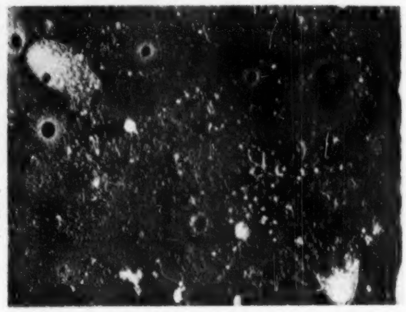


FIG. 4. Newly formed phage particles after lysis of cell, with cell debris.

"Cockade" PRM

Scientists at Fisons Milk Products Ltd have discovered a method of avoiding bacteriophage attack on starter cheese. They have developed the technique of removing the calcium from a medium, essentially a milk preparation in powder form, known as "Cockade" PRM (phage-resistant-medium). When reconstituted, PRM takes the place of normal milk as a medium for bulk starter cultures. It has a bacteriological count of 100 per ml., far less than that of normal milk.

Scientists feel that the experiments which lead to their discovery have also contributed a great deal to the understanding of cancer, since cancer and phage cells behave very similarly. Phage alone cannot reproduce, but needs a living cell to which it attaches itself and forces the host to build up new phage particles (Fig. 3). At the end of this cycle the host disintegrates (Fig. 4) and up to several hundred newly formed phage particles are released into the medium; they are then free to attack other non-infected cells.

It has been found that a concentration of phage that will cause complete lysis of starter in milk will not affect cheese-making if a PRM-based starter is used. Starter cultures that will grow in PRM will develop normally in spite of the heaviest phage contamination, for phage will not multiply in the new medium and any present will die out during incubation.

Reading microfilm with the "Dagmar".

Cheese manufacturers in the United Kingdom must apply to the appropriate Milk Marketing Board for consent to the use of PRM under the manufacturing rebate conditions.

The "Dagmar" Reader

A new, greatly improved, portable microfilm and microfiche reader has just been imported from Holland. It was developed by J. H. Mullens of The Hague for Dr L. J. van der Wolk, Librarian of the Delft Technische Hogeschool, who needed a portable reader which was cheap enough for a number of them to be placed about the college and thereby allow Microfiche (flat film, 9 × 12 cm.) copies of articles to be issued from the library instead of the journals.

The "Dagmar" reader is of the "mirror to table-top" type, the image being thrown on to white paper or card. As the mirror can be raised or lowered on its rods, magnification is variable, and this is important as reduction ratios between 12 × and 25 × are common. If placed on its back, the reader will project on to a wall and a number of students can study together. Enlarged photocopies on paper can easily be made with it. The bulb, a car headlamp, is fairly cheap; illumination is so good that no curtains or screens are needed in normally lit rooms.

The microfiche holder has two plates of glass hinged on one side. It has magnets which hold it in place over the aperture and a slight push moves it about until the desired page is found. The film holder (not in place when microfiche are being viewed) clips on to the casing and

has no pressure-plates which might scratch the film.

The instrument can be dismantled and packed into an eight-inch cube weighing 12 lb. The price is £37 to commercial and industrial users. Universities and large research libraries will now be able to have a few really portable instruments which can be "lent out" to departments and laboratories on demand.

Mental Health and Atomic Energy

A study group on mental health aspects of the peaceful uses of atomic energy was called together by the World Health Organisation (WHO) for a meeting in October at the Palais des Nations, Geneva. The meeting was under the chairmanship of Prof. Hans Hoff of Vienna. The group met to determine whether the increased use of atomic energy has brought in its train any mental-health problems; if so, to investigate the nature and extent of these problems, and to suggest scientific ways of dealing with them. Members of the study group were chosen from fields as different as psychiatry, atomic and radiation medicine, public health, social anthropology, and public information.

In his opening remarks to the study group, Dr M. G. Candau, WHO Director-General, stated that the peaceful use of atomic energy may bring a second industrial revolution, and added: "However, if we remember to what extent the first industrial revolution has affected the mental health of mankind, we cannot but wish that this new upheaval should find us better prepared to deal with its consequences. . . . WHO is already studying the physical aspects of atomic energy; but in view of its responsibilities in the field of mental health it must also examine to what extent anxiety about the potential hazards of atomic energy could in itself be a pathogenic factor and what steps could be taken in order to cope with it from the point of view of preventive medicine."

Measuring Hardness

A machine has been built by the National Physical Laboratory to calibrate hardness test blocks and so provide a national standard for the Vickers Hardness Scale, but the eventual goal of the research is to provide a standard also for the Rockwell Scale, which is used extensively in industry. When both hardness standards have been achieved, they will remove much of the confusion which exists today in hardness measurement throughout the world.

All practical methods use a diamond or ball which indents the test specimen when pressed into it with a known force. The NPL machine uses a diamond pyramid which can be loaded with 30, 50, 100, or 120 kg. correct to one part in 30,000 or better. The width of the indentation produced is then measured to better than ten-millionths of an inch using a microscope and a specially designed lighting system. From this, the Diamond Pyramid Number can be calculated. The machine is accurate to ± 5 DPN units, and is of a completely novel design. It will now be tested for long-term stability to ensure that its readings will not change from year to year.

60-Ton Transport Vehicle

What is claimed to be one of the largest road transport vehicles in the world is being built in Sydney to take two pieces of industrial machinery from Sydney to the iron and steel works at Port Kembla. The vehicle, a semi-trailer weighing nearly 60 tons—has ninety-six wheels. It is more than 100 feet in length. On each of its two journeys the vehicle will transport machinery weighing 117 tons for the new Australian Iron and Steel Co.'s Port Kembla mill.

Girls As Scientists

An appeal to girls to take up science and technology was made by Sir Edward Boyle, Parliamentary Secretary to the Ministry of Education.

Opening extensions to the Kesteven and Grantham High School for Girls, Sir Edward said that although nearly half the women between the ages of twenty and thirty-four were in gainful employment, too few of them were engaged in science and technology. This might be due, he suggested, to the feeling that science and technology were dirty jobs, which necessarily meant "messing around in overalls". But this was not so. "Much of the work involves simple first-class brain-power, research, and the ability to concentrate, and no one will have any doubt that the ablest women possess these qualities to the full."

Girls were fully the match for the boys at school but too few of them went on to the universities. "The number of girls in universities," he said, "is only one-third the number of men and only about 100 girls were in technological departments compared with about 5000 men. For every seven boys released by their employers for part-time day courses there is only one girl. This does suggest that there are pretty big resources which remain untapped."

Ageing on the Factory Floor

A series of studies on the employment problems of older men has been published in recent years by the Nuffield Foundation. An inquiry into the prospects of ageing men within a mechanised industry has been recorded by F. Le Gros Clark, M.A., for the Foundation as a study of conditions in a furniture factory. The concern of the Foundation, of course, is for the interests of those older men who wish to remain employed, so long as they can continue to work in comfort. In its own way their welfare is as important as that of retired and elderly persons.

Mr Le Gros Clark's report says that, though the furniture industry is not a very large one as industries go, its products are socially useful and familiar. Factory managements in other industries will be able to judge readily how far the findings and methods of research adopted would apply to their own workers. Only the mechanised production of furniture was examined, because conditions are more likely to resemble those of the future, when the ageing problem will have become more acute. It is suggested that wood, the material used, gives the furniture industry certain qualities peculiar to itself; furniture is not so responsive as are many other manufacturing industries to automation methods, because parts and products have to be to some extent handled and inspected at every stage. Some repairing and making good of parts and sub-units often have to be undertaken. It is believed that these characteristics may give the older men some measure of advantage, when supervisors have to adjust the work to their declining physical powers.

The method of the inquiry was to examine and discuss in detail the industrial and medical records and status of 251 older men, working manually under such factory conditions. Both the men still employed and the recent departures were carefully noted. None of them had been arbitrarily retired at the age of sixty-five; and few of them had retired on their own account at that age. Their numbers decline, of course, in each successive five years of life. But the report concludes that some working adjustments or concessions had to be made for about one in ten of the men in their late fifties, for about three in ten of those in their early sixties, for at least six in ten of those in their late sixties, and for practically all the working survivors who were in their seventies. The oldest among them was a man of seventy-six. Most of the 251 men studied were production operatives or factory labourers.

The writer gives numerous instances of the kinds of job adjustment that were effected. He shows that older men who have still some reserve of skill with hand tools can be employed in the repair shops of a large factory, and that this is where a few of them may frequently be found. It is noticeable, he says, that when transfers of this type have taken place, concessions in the hours worked by the men or in the pace of their work may become necessary. He estimates, however, that not more than 1% of the manual workers of a large factory would be so employed. The report suggests that in its bearing upon the employment prospects of ageing men the whole subject of repair work needs detailed survey. Unless an older man has acquired in his early days the necessary all-round experience, it is not easy for him to acclimatise himself to the demands of repair and maintenance work; and it is thus possible that one of their obvious ways of "easing up" in later life is becoming increasingly barred to the machine operatives and machine minders of today.

It is, states the report, the element of co-ordinated overall timing in production that is decisive in the industry. Under modern factory conditions it is becoming necessary to select men who can maintain the overall continuity; and as far as ageing men are concerned, it becomes a matter of sorting out what operations they can still perform without impeding the flow of production. It is felt that this task is probably growing increasingly difficult for the average factory supervisor or foreman.

New Australian Radio-Telescope in Use

A new radio-telescope now operating at Fleurs, about thirty-five miles from Sydney, Australia, is helping scientists to solve some of the mysteries of the solar system, and to study the effects of sunstorms on the earth. The telescope is equipped with sixty-four discs, eighteen feet in diameter, and from these a continuous picture of the sun is fed into a recording machine. A complete record of solar flare-ups is obtainable through cloud and other disturbances, and across hundreds of thousands of miles of solar atmosphere.

How Aborigines Keep Warm

An international scientific expedition is in Central Australia trying to find the secret of a body mechanism which enables unclothed aborigines to withstand winter temperatures down to four degrees below freezing point. The expedition is part of a world-wide investigation into how far the human body can withstand cold conditions from its own internal resources.

The party is moving into a remote area west of the Hermansburg Mission in the Northern Territory to continue work started twenty-five years ago by an Australian physiologist, Sir Stanton Hicks.

Brooms and Bombers

Although the connexion between brooms and bombers would at first sight appear to be slight, a recent investigation by Post Office engineers shows how the manufacture of the humble household broom nearly swept special aircraft from the skies.

Bombers and other aircraft of the Royal Air Force use radio-telephone channels to keep in touch with their control centres on the ground, and these channels were being jammed by radio noise on the same wavelength.

Aircraft flying over Devon, Wales, Northern Ireland, and the Home Counties were affected, and the Air Ministry asked the Post Office Interference Service if they could help to discover the source of the noise. As the radio noise could not be detected on radio receivers used on the ground, special recording apparatus was fitted in one of the aircraft which then flew over some of the affected areas and brought back a record of the noise. From these recordings PO engineers were able to deduce the nature of the apparatus likely to produce the interference. Widespread checks were made of hospitals, factories, and other organisations likely to use radio-type apparatus which would,

perhaps fortuitously, generate and transmit the radio frequency which was causing the trouble.

The cause was traced to a factory in Sussex where electronic apparatus was used for drying wooden billets used for making ordinary domestic broomheads. Co-operation by the factory director and the manufacturers of the equipment, the RAF and the Post Office enabled modifications to the equipment to be made which successfully cleared the trouble.

New Record Depth in Lake Baikal

In Lake Baikal, the world's deepest freshwater lake, a new record depth has been discovered—1940 metres, which is just over one and one-fifth miles. Until now it was believed that the lake's maximum depth was 1741 metres.

The discovery was made by scientists of the Baikal Limnological Station of the U.S.S.R. Academy of Sciences in an area to the east of Olkhon Island. Soundings there revealed a crevice going down to the depth of 1940 metres.

This crevice (now named the Olkhon Crevice) has been traced for 30 miles. It varies in width from about half a mile to a few dozen yards and is believed to be one of the manifestations of the "Baikal-Kosogol Fault".

A special expedition will begin further explorations of this deep-water area in the near future.

Standard Musical Pitch Broadcast Daily in United States

A musical tone of standard pitch (middle A at 440 cycles per second) is broadcast day and night by the United States National Bureau of Standards over its two short-wave stations. The tone is obtained from an electronic, crystal-controlled oscillator, and is accurate to better than 1 part in 100 million.

This little-known service is available to amateur and professional musicians, makers of musical instruments, and piano-tuners, provided they have a short-wave receiver. From the technical point of view, the standard pitch maintained by the NBS has the advantage that, unlike the material objects such as tuning-forks and organ-pipes previously used, it is not affected by the temperature of the surroundings.

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